Common Faults in Mist Propagation System Design and Operation©

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INTRODUCTION

Since 1936, when G.E.L. Spencer first set out the basic concept of mist propagation (MacDonald, 1986; Welch, 1970), most professional propagators have had some grasp of the principles involved. However, in this author's opinion they often manage to turn an essentially simple concept into a technical and commercial headache.

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.
- Poor maintenance routines.

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

Great attention should be paid to the chemical properties of the water used. Welch set out his views and methods robustly in 1970. With the benefit of more than 30 years of further practical experience, there is now a much clearer understanding of the difference between pH, alkalinity, and water hardness. In this paper the term alkalinity refers to the temporary hardness of water caused by the presence of dissolved carbonates and bicarbonates (see section on water chemistry, below). In watering systems alkalinity is a more important aspect of water quality than pH. Water with high alkalinity can seriously reduce a cutting's ability to form roots at all, let alone roots of good quality. Pouring hard water over cuttings results in a crust of lime scale forming over the callus and prevents roots from emerging. The added value of eliminating hard water on one pot plant nursery of 3 acres (1.2 ha) was calculated at £860 per week, plus a 25% increase in growth rates. Nothing pays faster than getting the water quality in a propagation unit right.

WATERLOGGING

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 a mist propagation unit, large droplets will 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 all propagators know what follows from that.

Propagators need to keep two essential functions of a mist system firmly in mind. The first is to reduce stem and leaf tissue temperatures so that cuttings can metabolise. The second is to increase the humidity of the air surrounding the cuttings, so that stomata stay open. However, in practice, too humid an atmosphere inhibits the uptake of CO_2. In the U.K. the use of evaporative cooling has positively depressed growth rates. The preference of Flowering Plants Ltd. is for the "wet to dry" cycle provided by mist.

SET-UP AND CONTROL

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

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.

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 leaching 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 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 referred to above.

WATER CHEMISTRY IN RELATION TO MIST SYSTEMS

It is important that growers understand what we mean by acidity (as measured by pH), water hardness, and alkalinity.

Acidity (pH). Technically, the pH scale is an inverse logarithmic scale ranging from 1 to 14, indicating the amount of hydrogen ion activity. Chemically pure water is pH 7, or neutral. Solutions of pH below 7 are considered acidic; those of pH above 7 are most properly termed basic. Soils with a pH above 7 are often termed alkaline. But note that alkaline is not the chemical opposite of acidic.

Advisory officers use pH measurements 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, growers who seek quality should interpret pH with due regard to the absolute quantities of the nutrients present in the sample, to the synergies and antagonisms between these nutrients, and to the buffering characteristics of the growing medium involved.

Hardness in Water. Technically, hardness is due to salts of calcium and magnesium in solution in water. In daily life, hardness in water forms lime scale, and prevents soap from producing lather. In horticulture, hard water prevents crop protection chemicals from working, locks up fertilisers, and coats plant roots. On cuttings, lime scale inhibits the emergence of roots from callus, reducing their number and rendering them white and brittle.

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.

Alkalinity. This is the temporary hardness caused by carbonates and bicarbonates, which can react with acids in solution to form salts. It is usually measured as the concentration of $CaCO_3$ or as HCO_3, in units of mols or parts per million (ppm). In British commercial horticulture, nitric acid is often used to reverse the formation of limescale and convert the minerals causing hardness into soluble fertilizer. Nitric acid dosing should be controlled through measurement of $CaCO_3$ and HCO_3 concentration (i.e., alkalinity), not pH.

As a general rule, where high levels of alkalinity are present in water that is used for mist propagation it can have a detrimental effect 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 leylandii* (syn. *Cupressus* ×*leylandii*) cuttings are particularly sensitive.

Acidification of the propagation water to reduce alkalinity (rather than pH), generally to no more than 60 $mg \cdot L^{-1}$ 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/waxy epidermis, which will improve resistance to fungal attack. The improved availability of calcium and nitrogen, which are by-products of dosage with nitric acid, play a role in this. Although there are conditions in which the use of sulphuric acid dosing is inevitable, we have always shied away from it for that reason.

Some propagators like to adjust dosage rates as they assess the progress of their cuttings. They tend to do so in steps of about 10 ppm (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 propagators 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.

Care must be taken not to over-acidify, as this will reduce the buffering capacity of the rooting medium. For example acidic water from a pH-controlled system damaged leaves and roots of a crop of polyanthus. High nitrogen levels made the leaves strongly convex. Antagonism depressed uptake of potassium to the point of necrosis. The roots became bright white, flushed with rose pink. The root tips became translucent, hairless, and brittle.

High levels of alkalinity seriously disrupt the mechanics of a 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. Regular cleaning by soaking them in diluted citric acid to remove lime deposits is advised.

Don't rush this. One very senior propagator decided to clean several hundred jets while the nursery manager was on holiday. He used nitric acid, which he diluted, but not enough. Citric acid has always been safer.

Filters should also be cleaned and lines flushed out, so as 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 1/2 h 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, clean them.

MONITORING AND THE PROPAGATION ENVIRONMENT

You cannot defy the laws of physics. Really accurate misting depends on electrostatically charged water particles diffusing through the air and being attracted to foliage, which must be sufficiently moist without having the stomata blocked by a film of water. Sloping sidewalls and low tunnels interfere with diffusion and appear to be associated with losses.

Fog systems can help to germinate seeds, to wean micropropagated 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.

To do that it is important to learn to "read the plant" and to understand how to undertake appropriate, systematic, small-scale trials.

The next frontier 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 should soon be 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 be as quick as a good grower?

LITERATURE CITED

MacDonald, B. 1986. Practical wood plant propagation for nursery growers. Timber Press, Portland, Oregon.

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