Project title:	Nursery Stock Propagation: Nursery evaluation and demonstration of the Evaposensor towards its commercial availability as a mist controller
Project number:	HNS 159
Project leader:	Chris Burgess, CB Consultant Agronomist
Report:	Annual Report
Key workers:	Chris Burgess, Author of report. Project manager. Richard Harrison-Murray, Research Consultant. Jill England, Horticultural Consultant, ADAS. Olga Grant, HNS Researcher, EMR. Supply of logging equipment.
Project locations:	Year 1: New Place Nurseries Ltd c/o John Hedger London Road Pulborough West Sussex, RH20 1AT Tel 01798 873774
Project co-ordinator:	Neal Wright Micropropagation Services Brookside Nurseries Kirk Ley Road East Leake Loughborough, LE12 6PE Tel 01509 856295
Date project commenced:	May 2007
Completion date:	April 2009
Key words:	Nursery stock propagation, Evaposensor, rooting, cuttings, mist, environment control,

CONTENTS

Grower Summary

Headline

The Evaposensor and a newly developed interface and controller from Electronic & Technical Services (ETS) Ltd gave excellent control of the mist environment in a commercial propagation nursery, and significantly improved rooting for 11 out of 31 cutting species. Trials are continuing, but the equipment is available now for nurseries to adopt.

Background and expected deliverables

Water stress on cuttings can still occur under mist or fog because existing controllers (such as simple timers, electronic leaf, or those using solar radiation integral) may fail to match misting frequency well enough to the needs of the cutting, especially as light level, humidity, temperature and air movement all vary during the day. The Evaposensor, with its wet and dry artificial 'leaves', responds to all these factors making it possible to detect and control the evaporative demand on cuttings in a reliable and reproducible way. The Evaposensor was invented at East Malling Research by Richard Harrison-Murray, originally as a research tool for controlling mist and fog environments, but it was never commercialised, partly because Clare Instruments Ltd, who made the Nobel humidity controller needed to interface with the Evaposensor, pulled out of this market in the 1990's. The objective of the project is to evaluate the technical performance of the Evaposensor on nurseries against their current mist control systems, and to help develop an alternative electronic interface to the Nobel, so that the Evaposensor can be taken up commercially by the industry. The comparative performance of the Evaposensor will also be tested in terms of rooting of leafy cuttings across a range of HNS subjects.

Summary of the project and main conclusions

The first year of the project was undertaken at New Place Nurseries, Pulborough, W. Sussex.

Control of rooting environment under mist

The Evaposensor's wet and dry 'leaves' contain platinum resistance temperature sensors. The wet 'leaf' is kept moist at all times via a wick in a distilled water reservoir and the dry 'leaf' may be either wet after misting or dry once the water has evaporated from its surface. Wet Leaf Depression is the temperature difference between the wet and dry 'leaves' of the Evaposensor, and is proportional to the rate of potential transpiration water losses by the cuttings (and hence cutting stress). A WLD set point could be set on both the Nobel and ETS controllers, and set points between 1.0 and 1.4 °C were used during the first year (typically 1.2 °C). The set point is the maximum WLD before a mist burst occurs. The dry leaf cycles between wetting from mist and consequent evaporative cooling (bringing the WLD to near zero), and re-warming as it becomes dry (with an increase in WLD up to the mist-trigger set point).

Mist Control Treatments

1 **Heron timer** - Grower's standard control system. Typically 2 sec. mist burst duration at a manually adjusted frequency according to the season and weather conditions. In summer up to a maximum frequency of about 1 burst per 10 mins down to about 1 burst per 30 mins or less in winter. Normally mist only during daylight hours or just one or two bursts during the night.

2 **Evaposensor via Nobel controller.** 2 sec. mist burst duration with frequency according to Wet Leaf Depression (WLD) set point and rate of evaporation. Linked to Heron to give a 2 sec. mist burst 'opportunity' every minute but mist only occurs when the (WLD) set point exceeded.

3 **Evaposensor via ETS Mk1 controller.** As Treatment 2 but using ETS Mk1 prototype controller.

Treatments 1 and 2 ran from May 2007, and Treatment 3 was added in September 2007 once the prototype ETS device was made available.

In addition to the Evaposensors that were controlling mist in Treatments 2 and 3, an additional Evaposensor was positioned in each treatment, linked to a logger, to monitor the actual WLD achieved. Other ambient environmental parameters including solar radiation in the glasshouse and relative humidity above the mist were also logged.

Photo GS1. Mist control and monitoring Evaposensors. Supported above cuttings to avoid shading of wet and dry ‘leaves’

The Evaposensor treatments maintained consistently low stress (low WLD) environments compared to the Timer treatments throughout the trial.

Figures GS1 and GS2 show how misting frequency automatically increased for the Evaposensor treatment in response to high solar radiation / low humidity resulting in a consistently low WLD compared to the static mist pattern from the Timer treatment where WLD could fluctuate significantly. While the Evaposensor treatment received more mist on average, misting was lower than the Timer treatment in the early morning or late afternoon, or on dull days.

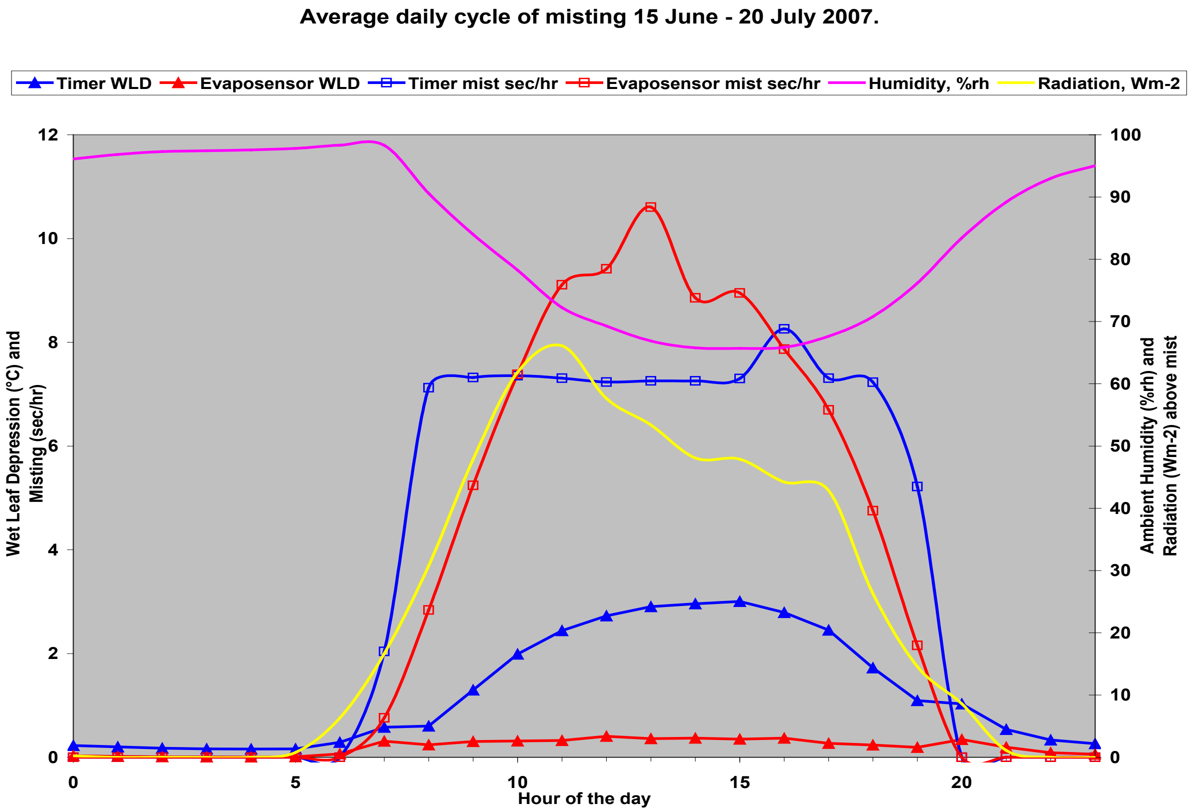


Fig GS1. Mean diurnal pattern of mist and ambient environment 15 June – 20 July 2007. Evaposensor / Nobel control kept WLD (cutting stress) low compared with the Timer control treatment. The Evaposensor applied more mist during the middle of the day on average but less early morning and evening.

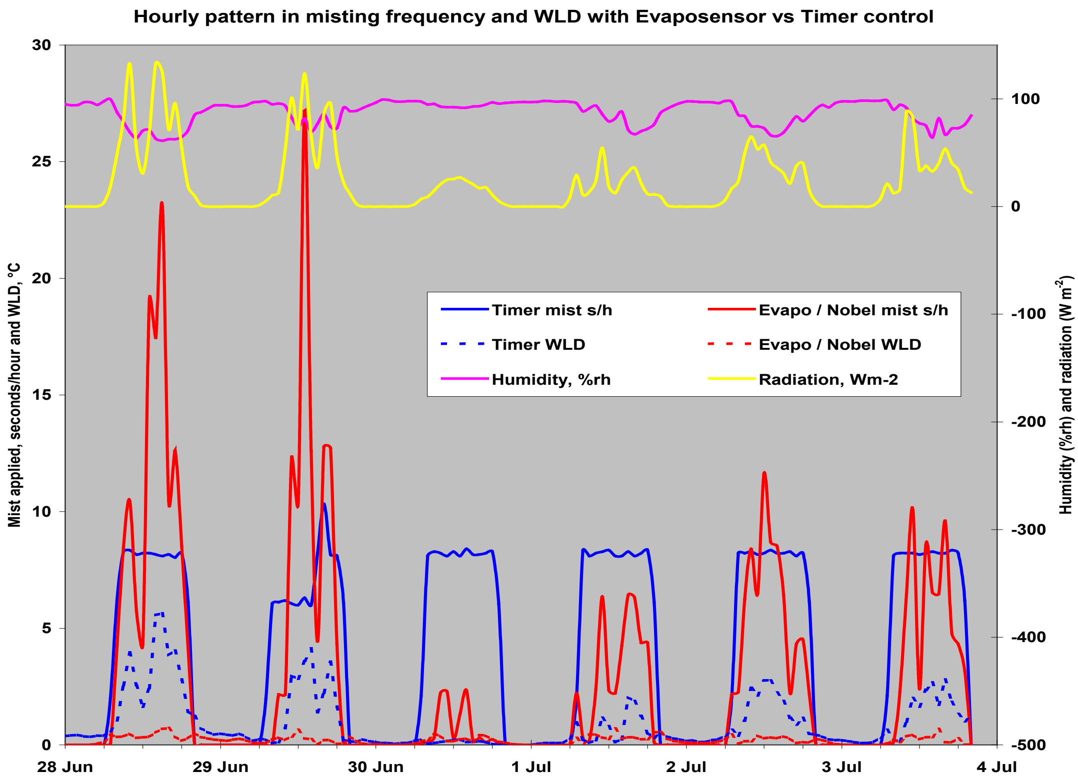


Fig GS2. Hourly mean values for ambient and mist environment 28 June – 3 July.

The Mk 1 prototype interface controller from ETS, which ran alongside the Nobel interface from September 2007, gave a comparatively good performance. Figure GS3 illustrates similar traces for both mist frequency and WLD achieved, as the mean diurnal pattern from mid March to mid April 2008. Trials are continuing with this ETS prototype at New Place Nurseries in Year 2, and also, on two additional nurseries, with a Mk 2 prototype incorporating its own 24V AC power supply for the solenoid and mist burst length and interval timers allowing it to be used independently of any other controller (such as the Heron used at New Place), if required.

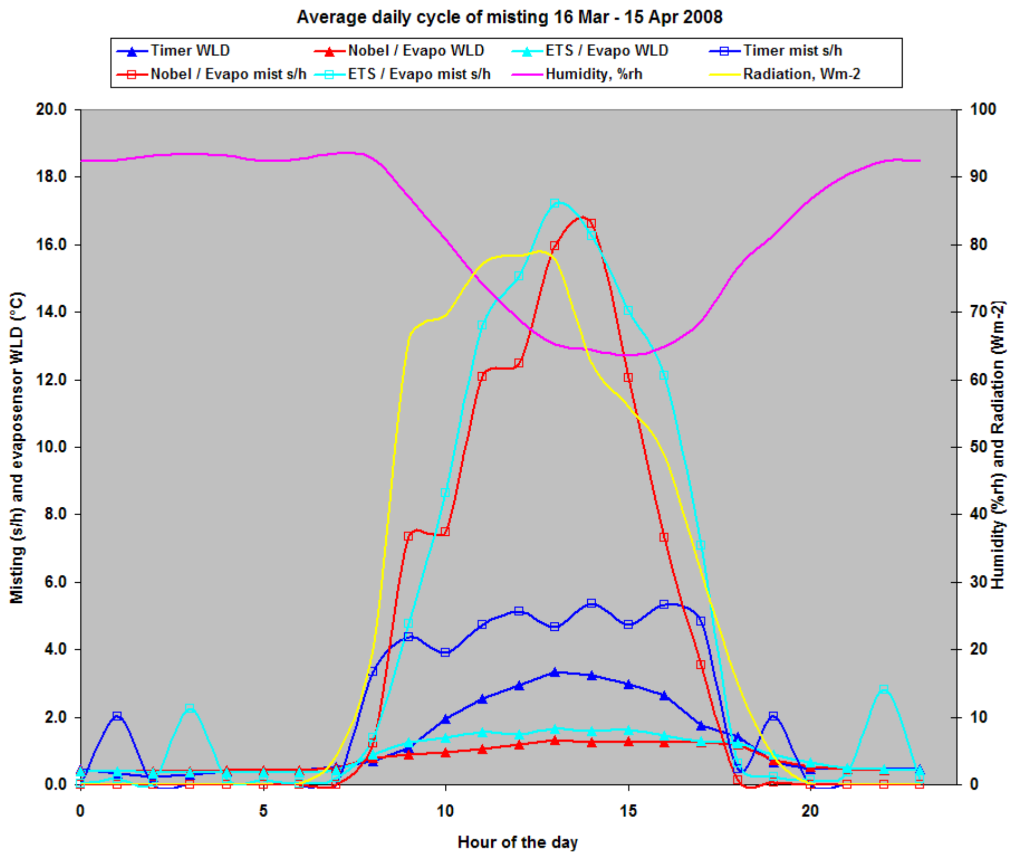


Fig GS3. Diurnal means plot 16 March to 15 April 2008.

Effect of treatments on rooting of cuttings

In Year 1, the main emphasis of the project was to begin to evaluate use of the Evaposensor under commercial nursery conditions and to develop an alternative interface to the Nobel so that other nurseries could begin using the Evaposensor. Batches of different cutting species were monitored, however, under the different treatment plots, and % rooting was recorded at the stage when cuttings were removed from the mist. A total of 31 batches of different species were propagated on the trial beds enabling comparisons of at least two of the trial treatments between 9 May 2007 and 26 March 2008, but because of the later introduction of the ETS treatment only six subjects included an ETS comparison in Year 1. For many subjects, rooting results were similar between Evaposensor compared to Timer mist control (averaging 77.6% for the

Evaposensor control and 73.8% for Timer). Some subjects, (see Table GS1) did, however, benefit from the typically higher amounts of mist provided by the Evaposensor treatments and gave noticeably improved rooting.

Other subjects rooted slightly less well under the Evaposensor treatment including *Convolvulus cneorum, Ceanothus* Zanzibar, *Elaeagnus* Quicksilver, *Halmiocistus sahucii*, *Rhododendron* Ginny Gee, and *Choisya* Smarty Pants (although misting treatments had no effect on two other *Choisyas*). For some subjects, there was a lot of tray-to-tray variation in rooting, and also some spatial patchiness in cutting failures and rots, and it was not possible to determine how much of this may have been linked to non-uniformity of mist deposition, variations in cutting quality or handling during preparation, or developments of 'hot spots' of *Botrytis* or other rots. Because a wide range of subjects were being propagated under each of the mist environments, the treatment set points were not likely to be optimal for all subjects.

Table GS1. Subjects showing most improvement in rooting with Evaposensor mist control compared to Timer control in summer and winter 2007.
Means of typically four replicates of 77 – 104 cuttings per tray. Rooting % with SE of mean.

	Mean % rooting	
Species	**Nobel / Evapo**	**Timer**
Berberis darwinii Compacta	80 ± 5.0	61 ± 12.0
Blueberry Chandler	39 ± 7.1	23 ± 7.2
Hydrangea petiolaris	88 ± 1.9	63 ± 24.0
Physocarpus Diablo	95 ± 0.9	87 ± 7.1
Prunus cerasifera Spring Glow	45 ± 6.9	31 ± 1.3
Solanum crispum Glasnevin	98 ± 1.4	84 ± 1.5
Spiraea Arguta	94 ± 1.0	65 ± 3.0
Spiraea japonica Goldflame	100 ± 0.0	85 ± 3.8
Spiraea nipponica Snowmound	96 ± 1.5	90 ± 1.6
Teucrium fruticans Compactum	44 ± 7.6	29 ± 8.2
Viburnum sargentii Onondaga	55 ± 7.1	34 ± 16.2

Grower response

Feedback about both Evaposensor control treatments from the manager and personnel involved with day to day running of the propagation unit at New Place Nursery has been positive. The automatic adjustment of mist with weather and light levels that is linked directly to the cuttings environment is seen as a great advantage, and it is accepted that manual adjustment of timer settings can never be as good. While, on average, the Evaposensor applied more mist to cuttings than their Timer settings, there were a number of periods, sometimes lasting for several days or weeks, with dull or cool weather when it applied less mist. The nursery accepts that different set points may be required for optimum results with different species, but growers can now trial these much more reliably by defining a WLD set point, which automatically takes account of the vagaries of weather changes and different ambient aerial environments between propagation units.

Photo GS2. Range of cutting subjects under Nobel / Evaposensor treatment plot 20 July 2007.

Financial benefits

- No financial benefits have yet been calculated from using the Evaposensor at this stage.

Action points for growers

- The Evaposensor shows considerable promise as a flexible and user-friendly system for controlling mist in propagation environments. The hardware is now available commercially. Growers wishing to start using Evaposensor mist control on their nurseries can obtain equipment from:

Evaposensor (specify PT100 type):

Skye Instruments Ltd
21 Ddole Enterprise Park
Llandrindod Wells
Powys LD1 6DF
Tel 01597 824811
www.skyeinstruments.com

ETS Evaposensor interface and controller:

Electronic & Technical Services Limited
106 Albion Street
Wallasey
Wirral
CH45 9JH
Tel 0151 639 4800
http://www.ets-controls.co.uk

- Pending further information following Year 2 of the project, the consultants involved in the project can offer further advice on setting up and using the Evaposensor for best results. For further technical advice on installation and use contact Chris Burgess or Richard Harrison-Murray via:

HDC Communications Manager
Scott Raffle
Horticultural Development Company
Bradbourne House
East Malling
Kent ME19 6DZ
Tel 01732 848383
www.hdc.org.uk

Science Section

INTRODUCTION

Preventing water stress on cuttings from transpiration losses is one of the most important things the propagator can do to help cuttings root. Stress can still occur under mist (or fog) because existing controllers (timers, electronic leaves, or even radiation integrators such as the Solarmist controller), may fail to match misting frequency well enough to the needs of the cutting to cope with fluctuations in light level, humidity, temperature and air movement. The Evaposensor, with its wet and dry artificial 'leaves', responds to all these factors making it possible to detect and control the evaporative demand on cuttings in a reliable and reproducible way. It allows optimum conditions for a particular subject to be quantified and reproduced in a way that is not possible with any other type of mist control. In previous research spanning over a decade at East Malling, Evaposensor control contributed to successful propagation of difficult to root species such as *Cotinus coggygria, Garrya elliptica, Acer cappadocicum and A. palmatum cvs.,* some *Rhododendron* and *Pieris cvs.*, and *Corylus maxima*. The Evaposensor was invented at EMR by Richard Harrison-Murray in the late 1980's, originally as a research tool for controlling mist and fog propagation environments. The objective of this project is to evaluate its performance by nurseries and enable it to be taken up commercially by the industry. The Evaposensor is also being evaluated on nurseries in LINK and other projects for irrigation scheduling.

The Evaposensor needs an interface electronic controller to enable the output from the wet and dry 'leaves' (platinum resistance temperature probes) to trigger mist or fog bursts – either in conjunction with existing timers (such as a Heron controller), or as a stand-alone controller. A Nobel humidity controller was originally used at EMR, but the manufacturers pulled out of this market in the late 1990's, so an alternative interface has been developed as part of the project by John Walker of Electronic & Technical Services (ETS) Ltd and is being evaluated alongside the obsolete Nobel device. The Evaposensor (Pt100 temperature element version) is currently available from Skye Instruments Ltd.

OBJECTIVES

i) Overall aims

To evaluate the Evaposensor as an environment controller for mist propagation in nursery situations against current grower systems, and, in conjunction with manufacturers, to develop and test a suitable interface to enable commercial uptake of the equipment.

ii) Specific objectives

1. Make Evaposensor-control of mist available to the industry by facilitating the development of a suitable interface by Electronic and Technical Services (ETS) Ltd (essentially an up-to-date replacement for the obsolete Nobel controller). Test the new interface and any alternatives developed by other manufacturers.

2. Evaluate technical performance of the Evaposensor in several commercial nursery environments against growers' current mist propagation control methods.

3. Assess comparative performance for a range of HNS subjects propagated by leafy cuttings, in terms of % rooting success, speed of rooting, and quality for potting on.

4. Collect data on key propagation environment parameters to help explain treatment differences.

5. Evaluate installation as a retrofit with nursery's existing mist systems, ease of use, and settings adjustment to aid the production of a User Manual.

6. Provide opportunities for other interested growers to become more familiar with the Evaposensor through visiting these nursery demonstrations, as well as written output from the project.

MATERIALS AND METHODS

Year 1

The first year of the project took place at one site, New Place Nurseries Ltd, Pulborough, W. Sussex.

Propagation facility

Glasshouse with open mist on sandbeds. Naan mist units (red nozzle – 61 litres/hr) on 50 cm risers spaced at 1.2 x 1.2 m. Two lines of beds either side of central path down glasshouse.

Shade screen operated automatically according to solar radiation level. In addition, further 'whitewash' shading was used on the glass during summer 2007.

Grower's conventional mist control via Heron MCI timers. Each 'station' operates a solenoid controlling four lines of five mist nozzles – an area of approx 4.8 m x 4.8 m (23 m^2).

Photo 1. Mist propagation facility under glass at New Place Nurseries used for project in Year 1

Mist Control Treatments

1 **Heron timer** - Grower's standard control system. Typically 2 sec. mist burst duration at a manually adjusted frequency according to the season and weather conditions. In summer up to a maximum frequency of about 1 burst per 10 mins down to about 1 burst per 30 mins or less in winter. Normally mist only during daylight hours or just one or two bursts during the night.

2 **Evaposensor via Nobel controller.** 2 sec. mist burst duration with frequency according to Wet Leaf Depression (WLD) set point and rate of evaporation. Linked to Heron to give a 2 sec. mist burst 'opportunity' every min. but mist only occurs when WLD set point exceeded.

3 **Evaposensor via ETS Mk1 controller.** As Treatment 2 but using ETS Mk1 prototype controller.

Each treatment was applied to a single 23 m^2 plot (4 mist lines) down the south side of the glasshouse.

The Nobel controller was installed in early May, and the experiment ran with a comparison of just Treatments 1 and 2 from 9 May until 25 September 2007 by which time the ETS unit had been developed and was installed to run as Treatment 3 alongside.

Photo 2. One Evaposensor linked to Nobel or ETS interface to control mist burst frequency and the other Evaposensor connected to logger to monitor environment achieved. PAR quantum sensor to record light levels also shown.

Cutting species

Between 9 May 2007 and 26 March 2008, a total of 31 batches of different species were propagated on the trial beds enabling comparisons of at least two of the above treatments (see Results for details).

Cuttings were typically rooted into 84 or 104 cell trays. Where possible, four replicate trays of each species were monitored under each mist control treatment, although for some subjects propagated in small numbers, only two or three replicates were available. As there was no replication of mist control plots, some attempt was made at placing assessed trays in comparable zones on the different mist controlled beds (ie trying to avoid confounding of positional effects such as distance from the glass wall or heating pipes with mist control treatment).

Records were made of the date stuck, number of cuttings per tray, and date removed from mist (ie when sufficient rooting had occurred for potting on). A simple count per tray of 'viable plugs for potting' was made when the cuttings were removed from the mist, and this was used to calculate the 'percentage rooted'. The decision on when to remove cuttings from the mist and assess them was made by the grower based on inspection and commercial experience. In most cases cuttings from all treatments were removed at the same time.

Environment monitoring

A DL2 logger (Delta-T Devices Ltd) and Skye Datahog (Skye Instruments Ltd) was used to monitor relevant parameters both in the cuttings mist environment and ambient conditions inside and outside the glasshouse.

The amount of time when misting occurred was recorded by counting AC pulses (50 Hz) delivered to the solenoids on each of the bed treatments during mist bursts, via counter channels on the DL2. From this, the mist duration in seconds per hour could be calculated. As the length of mist bursts was 2 sec for each treatment (as controlled by the Heron), this was proportional to the number of mists bursts per hour.

The evapotranspirative environment around the cuttings was measured with an Evaposensor in each treatment. 'Wet leaf' and 'Dry leaf' temperatures were logged by the DL2, so the WLD could be calculated. Additional Evaposensors were used for controlling mist on the Nobel and ETS treatments as the same unit could not be used for both tasks. It was important to position Evaposensors so that their 'leaves' were not shaded from either solar radiation or mist by the cutting foliage, which meant supporting them on a wooden block between cutting trays (Photo 2).

Light levels were recorded on the DL2 using a photosynthetically active radiation (PAR) quantum sensors at cuttings level and another placed on a shed roof outside the glasshouse. This was primarily to allow relative levels to be compared. A shade screen in the glasshouse was closed under bright conditions. The relative 'PAR-in' and 'PAR-out' values enabled an estimate of when the shading was in place, as this was controlled automatically for the whole glasshouse independently of our experiment.

The sand beds on which the cuttings trays were placed had bottom heat facility. A temperature probe was placed in the sand on the Timer and Nobel treatment beds linked to the DL2 logger.

A Skye Datahog fitted with a relative humidity, temperature and radiation sensor (W/m^2) was hung on a glasshouse stanchion above the mist beds but underneath the shade screen. This gave a measure of the glasshouse ambient RH%, air temperature and light level.

Both the Skye Datahog and Delta-T DL2 loggers were set to log values every 30 minutes. For the DL2 records of temperatures and PAR measurements, the logged values were means of 1 min samples, and the solenoid activity counts were means of 10 min samples (hence misting rate in s/h was 10 min sample x 6 / 50 Hz).

Analysis of environment data

Data was downloaded periodically from the loggers, and analysed using an Excel spreadsheet. Data was split into 1 month periods as convenient blocks of time for summarising means such as daily or diurnal averages, and also to observe changes with season of the year.

It was important to correct any 'zero error' differences in the readings from the Wet and Dry leaves from the Evaposensor. The absolute temperatures of these probes were not required, but only the temperature difference between them. Typically the wet probe would be slightly cooler due to evaporative cooling than the dry probe. Very small differences in electrical resistance in the cabling circuit using Pt100 probes in particular, will register as large temperature differences. The measured values in the raw data therefore needed correcting using a 'zero offset value' as recorded when both temperature probes were placed in a beaker of water, stirred and allowed to equilibrate for 5 minutes or so.

The half-hourly data from both the DL2 and Datahog loggers were combined and synchronised on a spreadsheet. Means were obtained using Pivot tables so that the following graphs could be obtained:

a) Hourly means i.e. half-hour logged values averaged to give hourly averages over the whole logged month. A detailed picture of the data could be viewed for selected periods of interest of a few days at a time.

b) Daily means i.e. means of all values per day to give a single daily mean for each day over the logged period.

c) Diurnal values i.e. values averaged over the month's data for each of 24 hourly values during the day.

The following variates could be graphed as required:

i) Ambient air temperature in glasshouse - °C
ii) Ambient relative humidity in glasshouse - % RH
iii) Ambient radiation in glasshouse - W / m^2
iv) Amount of shade - %
v) Mean Wet Leaf Depression (WLD) for each treatment - °C
vi) Mean amount of misting for each treatment - s / h

Measurement of mist deposition uniformity

The mist distribution appeared uniform visually, but there was some doubt over its uniformity when some Botrytis infection and necrosis of some cutting species appeared in patches during late summer 2007. It was not clear whether localised excessive wetting may have contributed to the problem. Uniformity was measured on 25th September 2007 by supporting 30 Petri dishes of 88 mm diameter on upturned plastic cups in a 5 x 6 square array spaced at 0.3 m over one bed, running the mist for a total of 60 seconds, and weighing each dish before and after misting (Photo 3).

Photo 3. Testing mist distribution uniformity at New Place Nurseries, September 2007

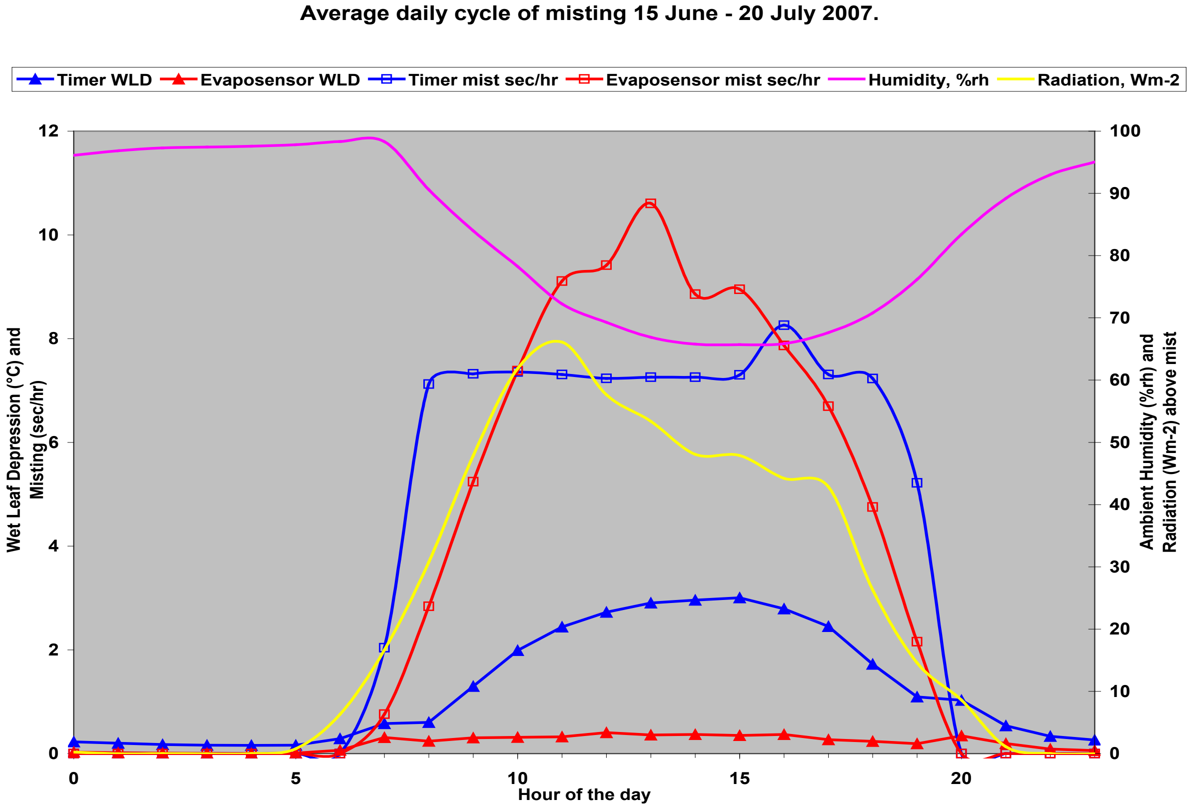
RESULTS & DISCUSSION

Control of rooting environment under mist

During most of the summer period in 2007, the Timer treatment bed was set to receive a 2 second mist burst every 15 or 20 minutes (timer adjusted occasionally by grower) between 7:30 and 19:30. No mist was given between these times overnight. The Evaposensor / Nobel controlled treatment was given a 1.2 °C WLD set point, therefore allowing the 1 min x 2 sec. burst pulses from the Heron through only when the WLD exceeded this value. In practice, a single mist burst, or occasionally 2 bursts, wet the dry leaf sufficiently to rapidly bring the WLD down to near zero and prevent further misting until the WLD exceeded 1.2 °C again.

The early results with the Evaposensor control via the Nobel only compared to the simple Timer control were encouraging and showed that the Evaposensor maintained a much more consistently low evaporative stress (low WLD) environment for the cuttings, by varying misting frequency according to the weather. Fig 1, below, shows the mean diurnal pattern of ambient humidity and radiation, and for the two treatments, misting pattern and WLD achieved, over a month in June - July 2007.

Fig 1. Mean diurnal pattern of mist and ambient environment 15 June – 20 July 2007.



Evaposensor / Nobel control kept WLD (cutting stress) low compared with the Timer control treatment. The Evaposensor applied more mist during the middle of the day on average but less early morning and evening.

Note that the *mean* WLD achieved for the Evaposensor / Nobel treatment during the day (0.3 °C) was much lower than the 'trigger' set point maximum of 1.2 °C. In contrast, the Timer treatment peaked at 3.0 °C on average.

Figure 2 shows 24 hour mean values over this month and shows how the Evaposensor control varied mist according to changes in the weather, giving more when ambient solar radiation was higher and humidity lower, but giving less mist on average than the Timer treatment on dull and more humid days. WLD was kept consistently low by the Evaposensor treatment but fluctuated, and was nearly always higher from the Timer treatment. Note that mist was only operational for half the 24-hour period, so the peak misting of 8.6 s/h for the Evaposensor treatment on 9 July corresponds to an average of a 2 sec burst every 7 min. during the day.

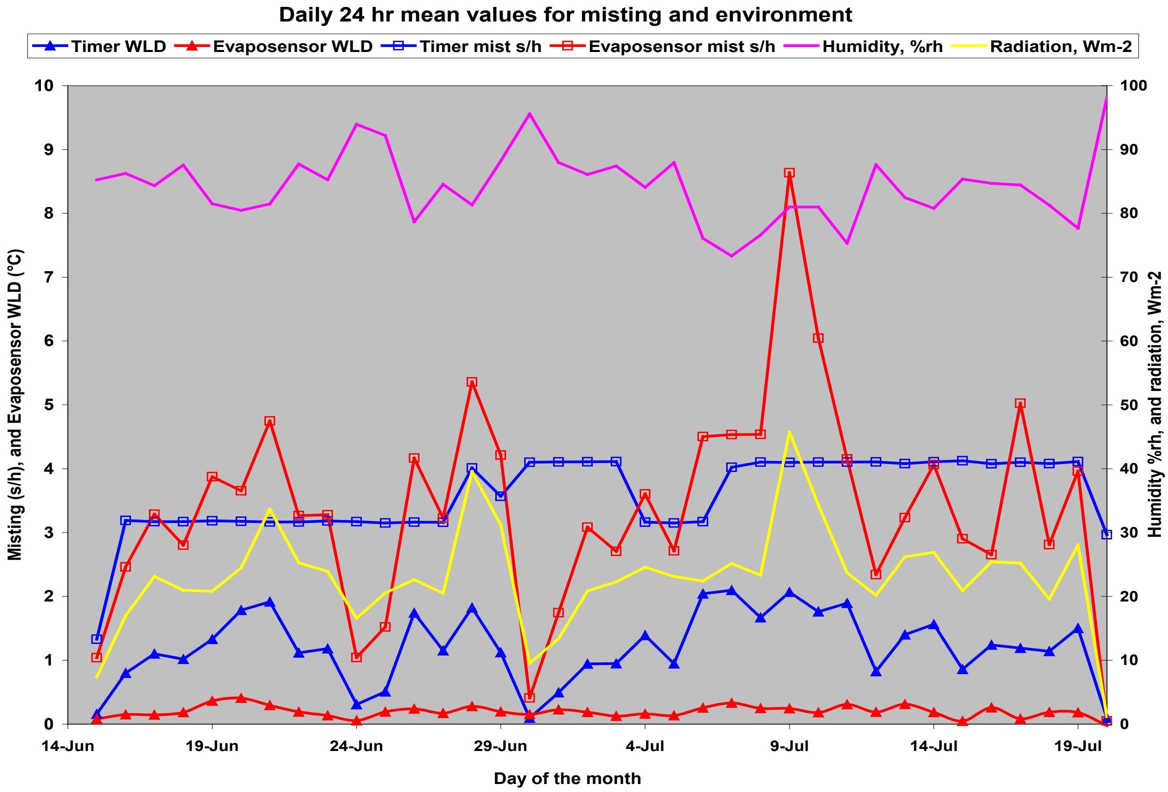


Fig 2. Daily mean values for ambient and mist environment 15 June – 20 July 2007.

Figure 3 shows in more detail for a 6-day period with variable weather (ref. light and humidity) how the misting frequency of the Evaposensor treatment varied during and between days accordingly.

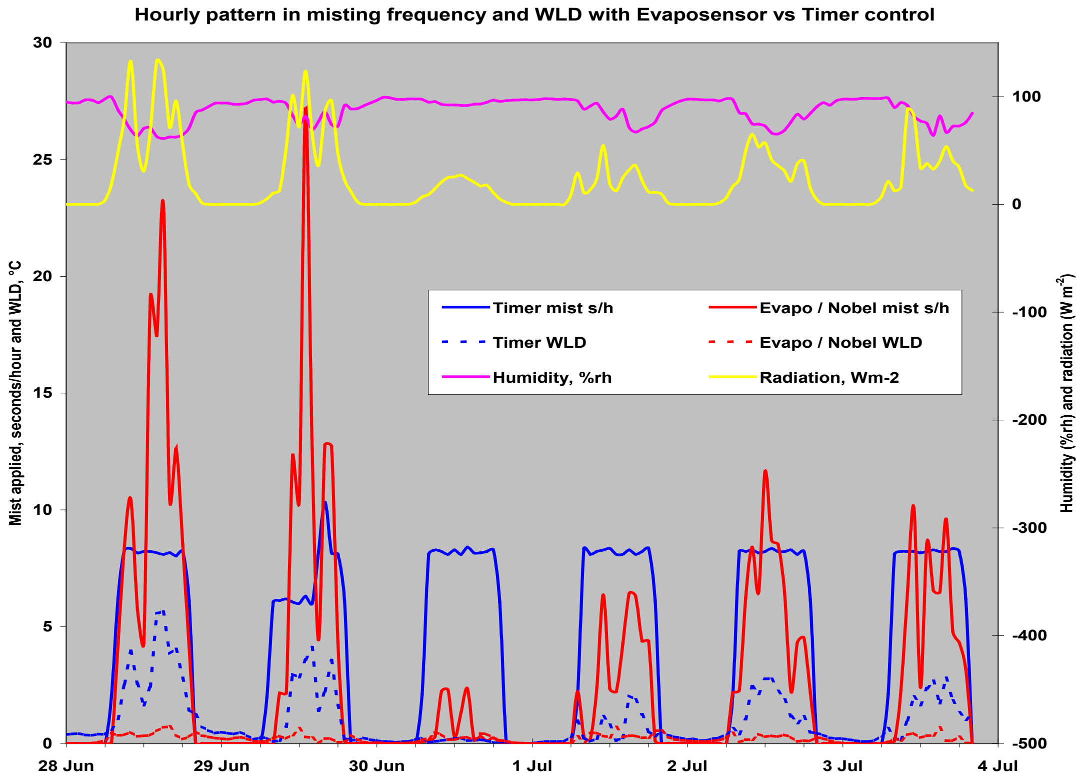


Fig 3. Hourly mean values for ambient and mist environment 28 June – 3 July.

Performance of ETS interface for Evaposensor vs Nobel interface

The ETS Mk1 prototype was installed as an interface for the Evaposensor at New Place Nurseries on 25 September 2007 to run as a third treatment alongside the Nobel / Evaposensor plot and Timer controlled plot.

Photo 4. Mk1 ETS prototype controller interface for the Evaposensor installed at New Place Nursery in September 2007

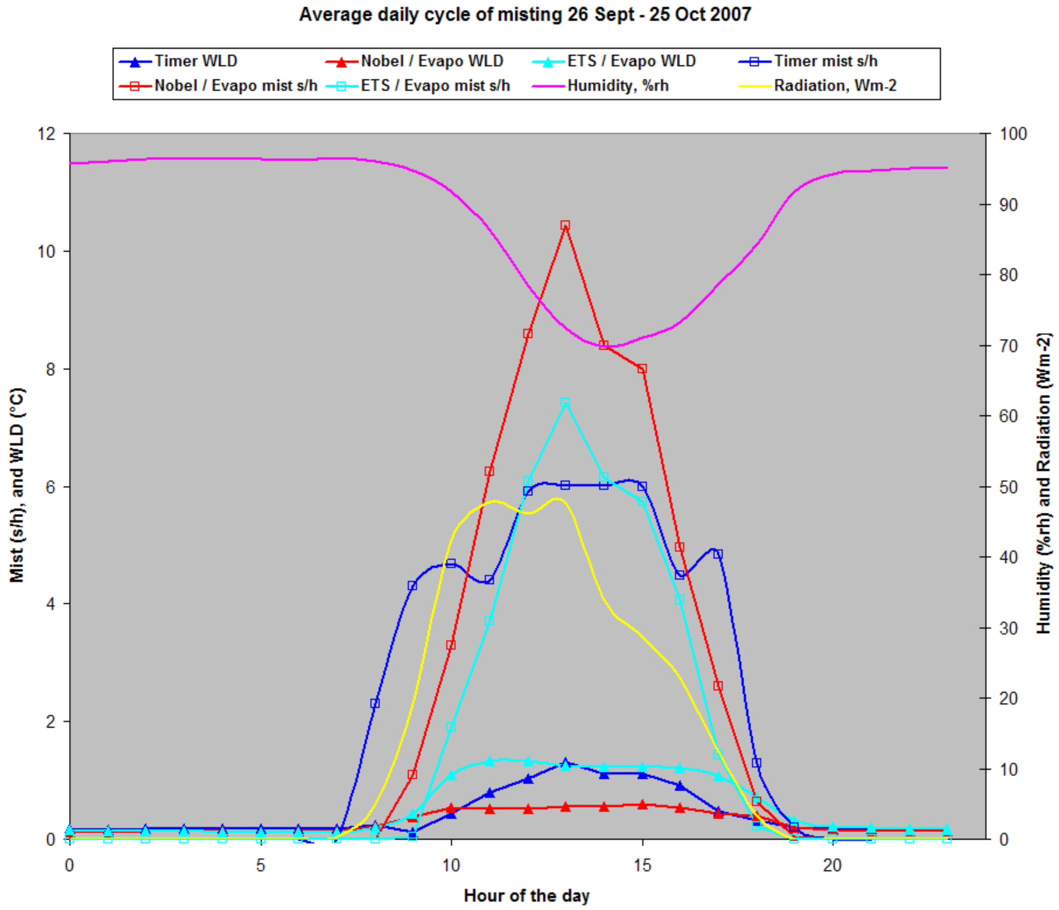
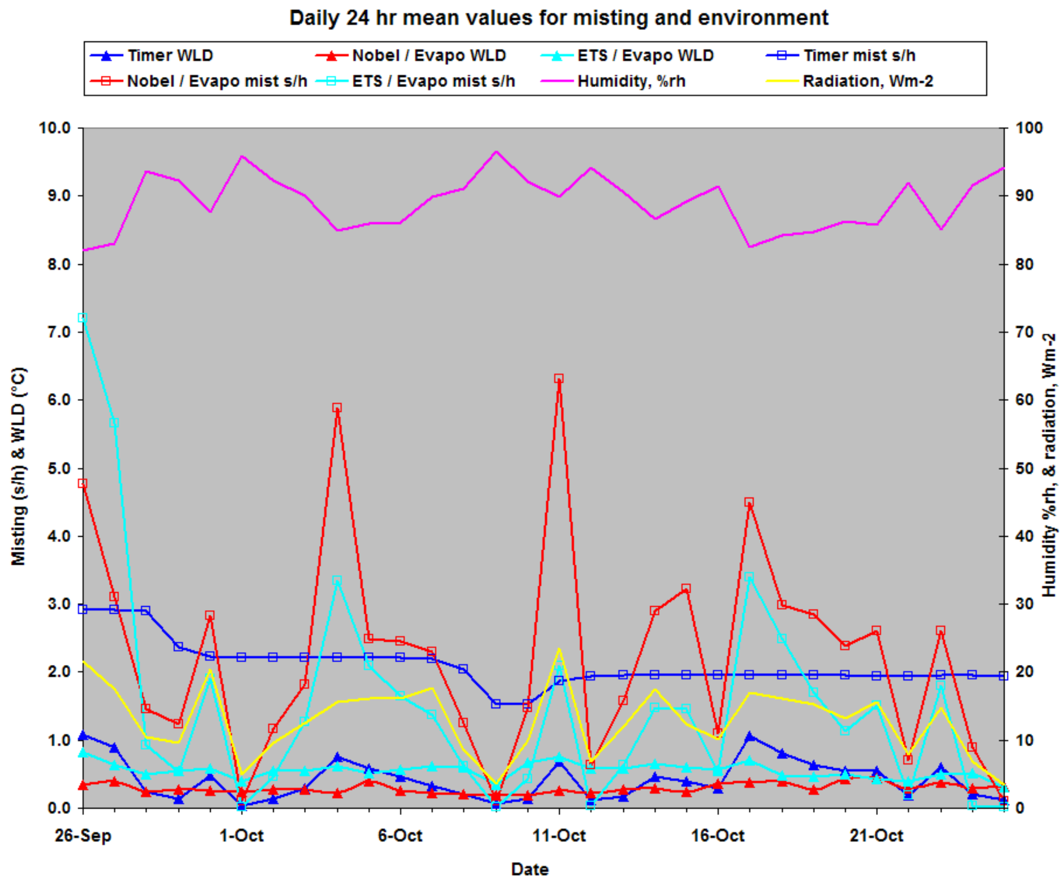


Fig 4. Mean diurnal data for 26 September – 25 October 2007 showing comparison of ETS and



Nobel control compared to Timer plot.

Fig 5. Daily means data for 26 September – 25 October 2007 showing comparison of ETS and Nobel control compared to Timer plot.

Figs 4 & 5 show the first downloads of environment data including both ETS and Nobel treatments, and show that misting followed broadly similar patterns for both, but that the achieved WLD appeared to be higher for the ETS treatment. This was due to an incorrect zero correction for the monitoring Evaposensor probe and was subsequently corrected. Like the Nobel interface, the ETS controller has a facility to 'zero adjust' the Evaposensor when both probes are maintained at the same temperature by inserting them in a beaker of stirred water and left for 5 minutes to stabilise.

Figs 6 – 8, below, show relatively similar patterns for misting and WLD control achieved between the Nobel and ETS Evaposensor treatments over the period from mid February to mid March. This has helped give confidence that the ETS interface should be a suitable replacement for the obsolete Nobel controller.

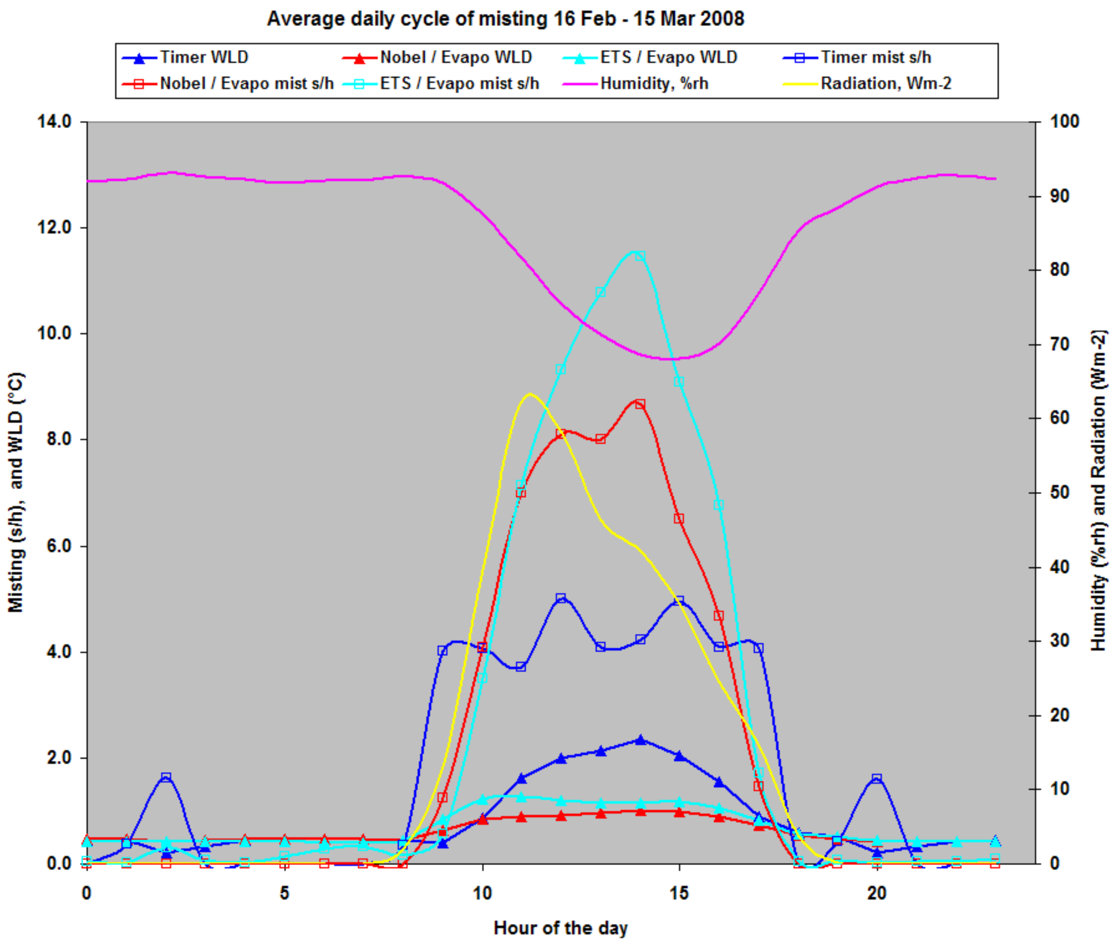
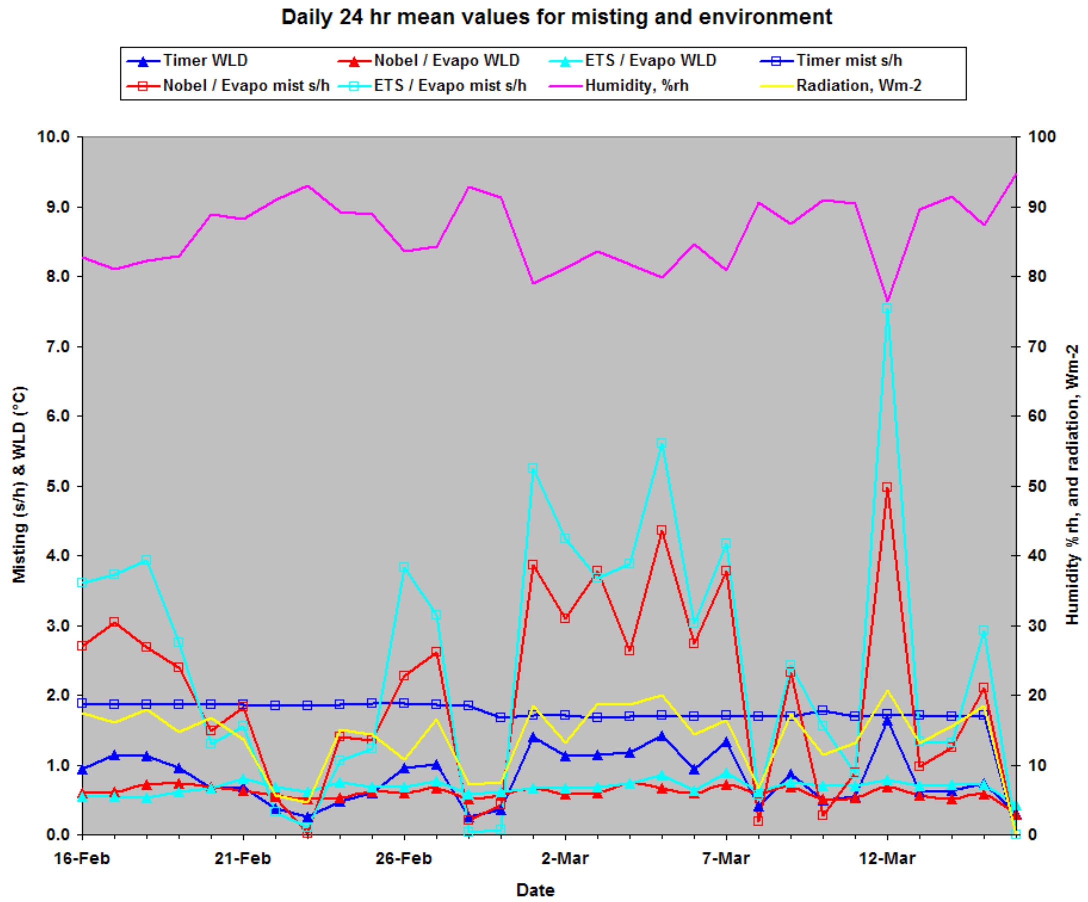


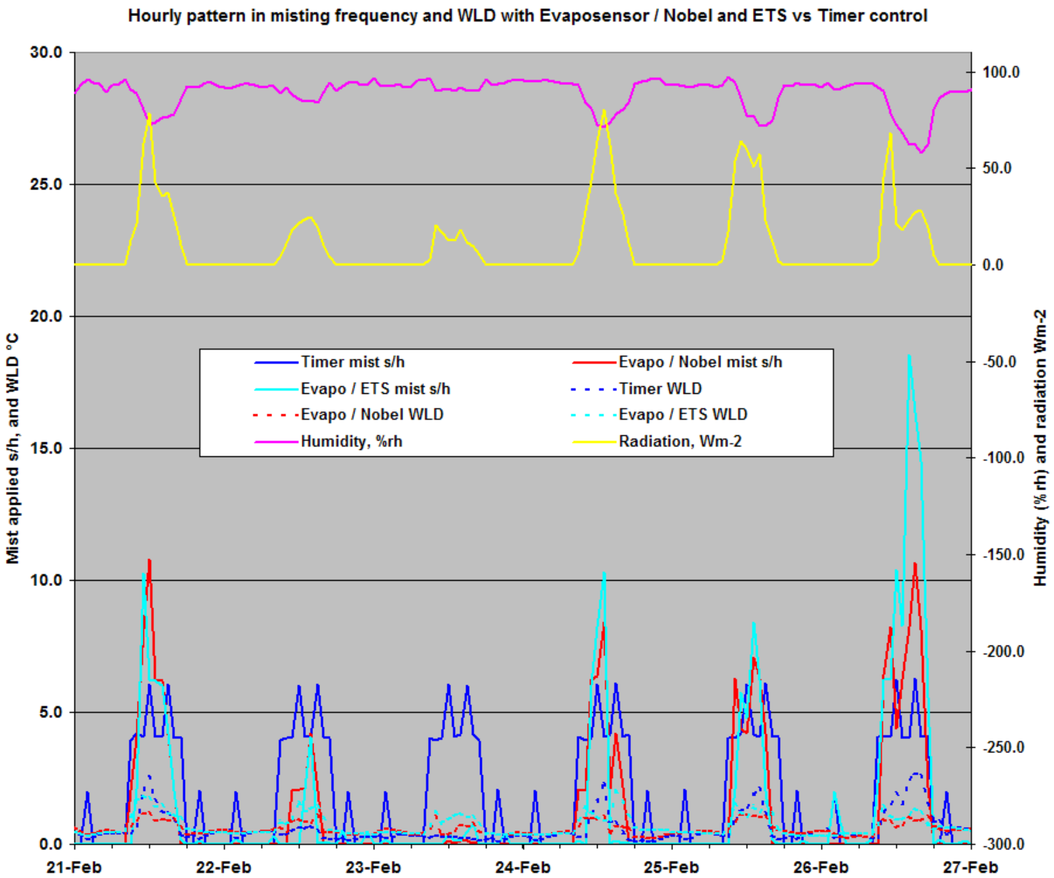
Fig 6. Diurnal plot 16 February to 15 March 2008. Nobel and ETS Evaposensor control giving broadly similar control of the mist environments.

Fig

Fig



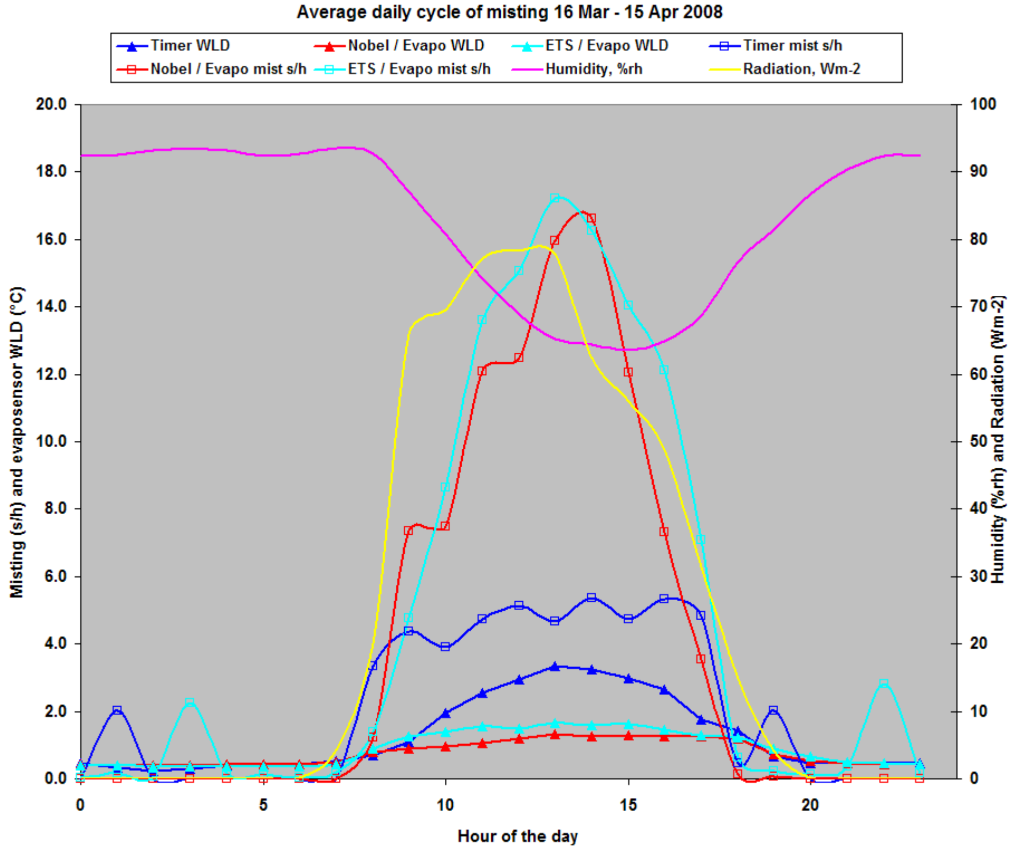
Daily 24 hr mean values for misting and environment
Timer WLD
Nobel / Evapo WLD
ETS / Evapo WLD
Timer mist s/h
Nobel / Evapo mist s/h
ETS / Evapo mist s/h
Humidity, %rh
Radiation, Wm-2
Misting (s/h) & WLD (°C)
Humidity % rh, and radiation, Wm-2
16-Feb
21-Feb
26-Feb
2-Mar
7-Mar
12-Mar
Date



Hourly pattern in misting frequency and WLD with Evaposensor / Nobel and ETS vs Timer control
Timer mist s/h
Evapo / Nobel mist s/h
Evapo / ETS mist s/h
Timer WLD
Evapo / Nobel WLD
Evapo / ETS WLD
Humidity, %rh
Radiation, Wm-2
Mist applied s/h, and WLD °C
Humidity (% rh) and radiation Wm-2
21-Feb
22-Feb
23-Feb
24-Feb
25-Feb
26-Feb
27-Feb

Finally, Figs 9 – 10 covering the March – April 2008 period, showed that both Evaposensor treatments continued to function well and Fig 10 shows how mist frequency increased from early April onwards in line with increasing amounts of solar radiation, while low WLD status was maintained.

Fig 9.



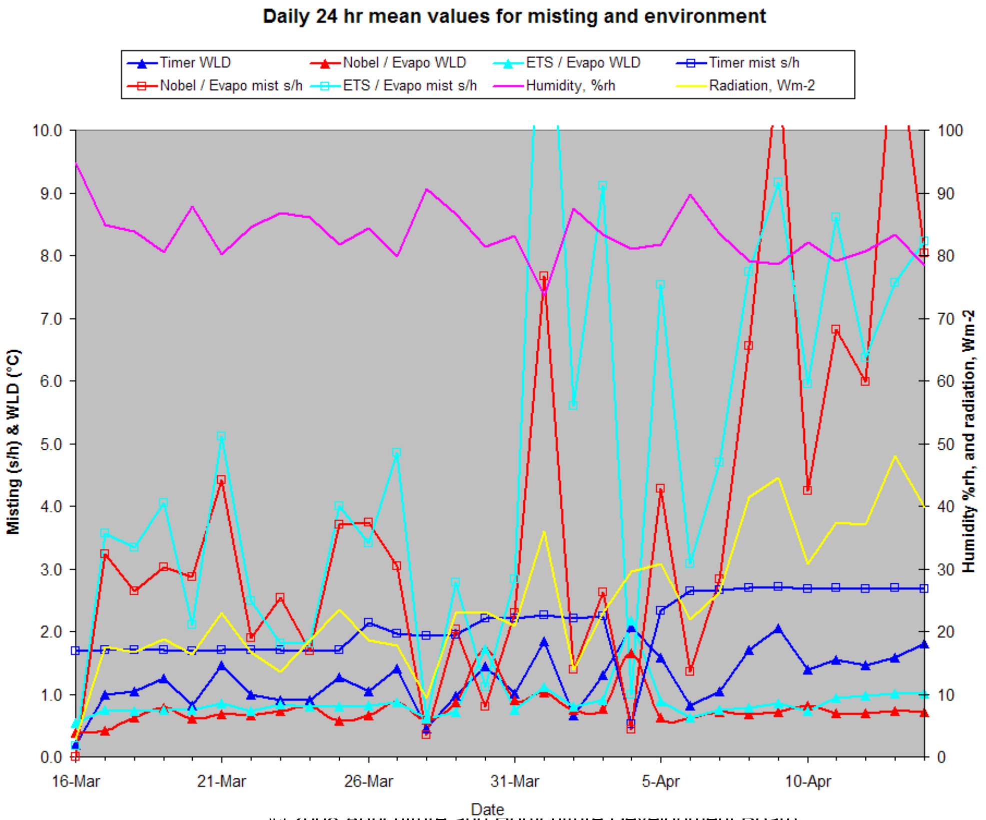
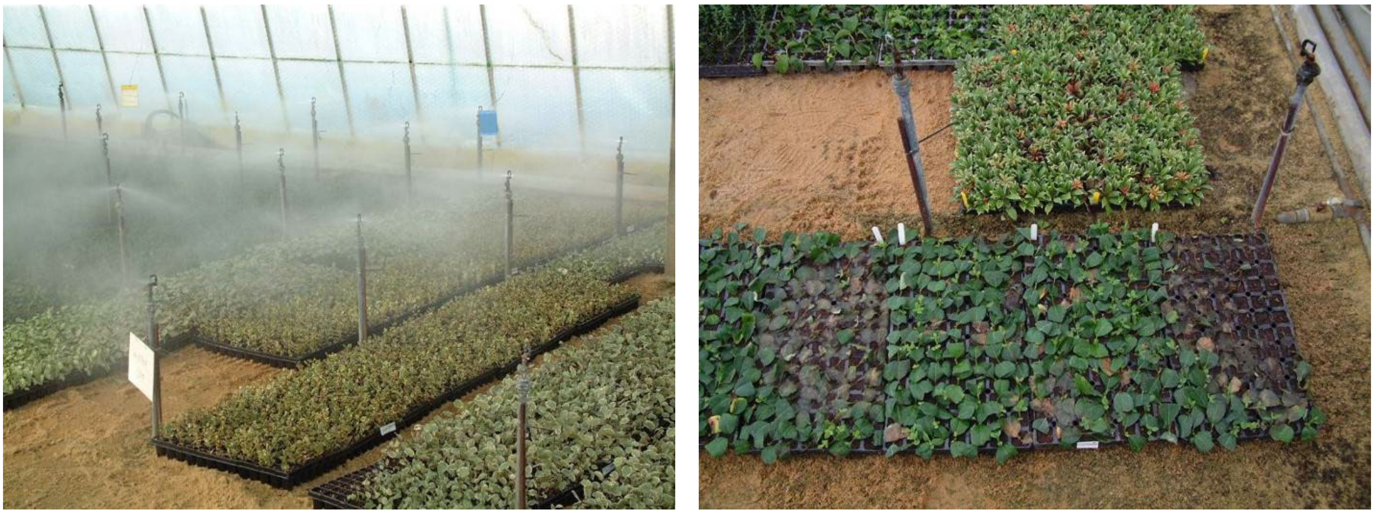


Fig 10. Daily means plot 16 March to 15 April 2008.

Uniformity of mist deposition

Visually, the Naan mist nozzles appeared to be giving uniform mist deposition over the beds, but during summer 2007 some cutting failures and rots were occurring on some subjects and appeared to be in distinct patches (Photos 5 – 6). It was thought that unevenness of mist deposition might be responsible, so this was measured on 25th September 2007.



Photos 5 & 6. Mist deposition and disease patches on *Lonicera* 'Graham Thomas'

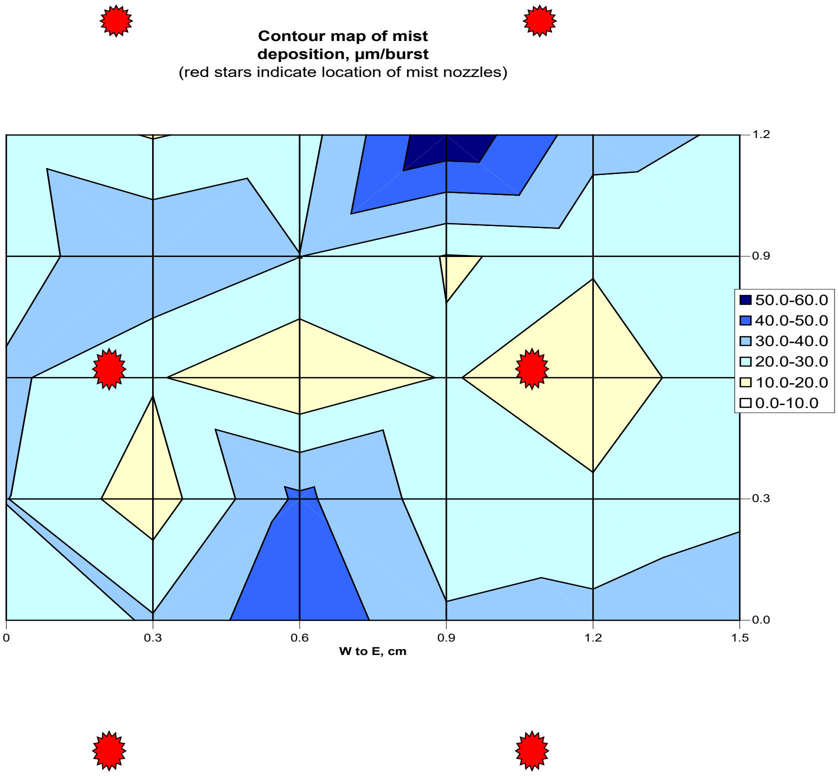


Fig 11. Contour map of mist deposition in relation to mist nozzles

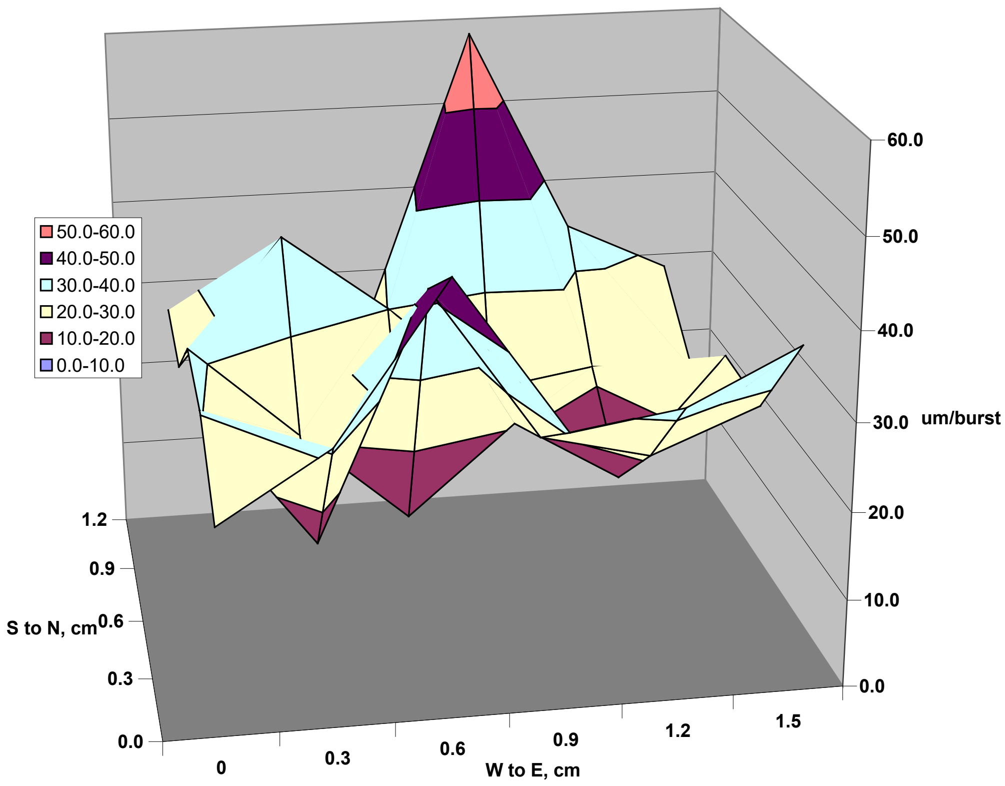


Fig 12. 3D distribution map showing large variation in mist deposition.

Figs 11 and 12 show that deposition was quite uneven with two peaks in deposition over the area measured. The coefficient of uniformity (CU) was 73% and scheduling coefficient (SC) value was 2.7, ie the driest areas were receiving a little over a third of the average deposition. Deposition would need to be measured over a larger area covering more nozzles to know if it was a systematic variation related to nozzle spacing or whether it was due to other factors such as variables in nozzle manufacture or a build-up of hard water deposits on the jet or anvil. It is possible that excessive localised wetting could encourage the development of rots such as *Botrytis*, but the patches could also be the result of rots spreading radially from a single infected cutting, or related to the quality of cuttings, and again this would require further investigation.

Effect of treatments on rooting of cuttings

For many of the species rooting results were broadly similar under Evaposensor compared to Timer mist control. There was a slight advantage for the Evaposensor when all species were averaged with the Nobel / Evaposensor treatment giving a mean rooting of 77.6% compared to 73.8% for the Timer (Table 1). Insufficient batches had been propagated under the ETS / Evaposensor treatment by late March 2008 to make a valid comparison from an overall mean.

Some subjects (highlighted in bold in Table 1) clearly benefited from the improved control and generally higher amounts of mist under the Evaposensor treatment including, in particular, *Berberis darwinii* Compacta, *Solanum crispum* Glasnevin, *Spiraea* Arguta, *S. japonica* Goldflame, *S. nipponica.* Snowmound and *Viburnum sargentii* Onondaga.

In contrast, other subjects rooted less well under the Evaposensor treatment. These were *Convolvulus cneorum, Ceanothus* Zanzibar, *Elaeagnus* Quicksilver, *Halmiocistus sahucii*, *Rhododendron* Ginny Gee, and *Choisya* Smarty Pants (although misting treatments had no effect on the other two *Choisyas*).

Table 1. Rooting results for subjects propagated up to end March 2008.

Means of typically four replicates of 77 – 104 cuttings per tray. Rooting % with SE of mean. Species in **bold** showed most improvement in rooting under Evaposensor mist control compared to Timer control.

	Mean % rooting					
Species	**ETS / Evapo**	**Nobel / Evapo**	**Timer**	**Date stuck**	**Date removed**	**Weeks in propagation**
Alnus glutinosa Imperialis	-	50 ± 2.9	42 (n=1)	13/06/07	24/07/07	5.9
***Berberis darwinii* Compacta**	-	80 ± 5.0	61 ± 12.0	16/10/07	15/01/08	13.0
Blueberry Chandler	-	39 ± 7.1	23 ± 7.2	14/05/07	17/09/07	18.0
Buddleja davidii Blue Horizon	-	100 ± 0.0	100 ± 0.0	09/05/07	24/05/07	2.1
Caryopteris Worcester Gold	-	97 ± 0.5	98 ± 1.1	09/05/07	26/05/07	2.5
Ceanothus thyrsiflorus repens	94 ± 1.0	91 ± 4.0	96 ± 3.2	26/09/07	10/12/07	10.7
Ceanothus Zanzibar	-	63 ± 5.7	77 ± 4.5	26/09/07	16/01/08	16.0
Choisya Smarty Pants	55 ± 5.8	-	80 ± 5.7	01/10/07	16/01/08	15.3
Choisya Sundance	71 ± 2.3	72 ± 2.6	-	26/09/07	11/12/07	10.9
Choisya White Dazzler	65 ± 3.4	-	65 ± 5.5	26/09/07	11/12/07	10.9
Cistus Sunset	96 ± 1.0	94 ± 3.2	95 ± 2.7	06/02/08	25/03/08	6.9
Convolvulus cneorum	-	81 ± 4.4	99 ± 0.6	n/a	16/07/07	n/a
Cornus alba Elegantissima	-	42 ± 5.6	48 ± 7.6	26/06/07	17/07/07	3.0
Daphne Eternal Fragrance	-	79 ± 2.3	79 ± 4.6	14/05/07	04/07/07	7.3
Elaeagnus Quicksilver	-	43 ± 7.3	55 ± 7.3	26/06/07	24/07/07	4.0
Halimiocistus sahucii	35 ± 1.4	63 ± 6.1	79 ± 7.2	05/02/08	25/03/08	7.0
Hydrangea petiolaris	-	88 ± 1.9	63 ± 24.0	07/06/07	17/09/07	14.6
Lavatera Blushing Bride	-	88 ± 1.3	87 ± 4.0	09/05/07	01/06/07	3.3
Lavendula Hidcote	-	99 ± 0.6	99 ± 0.6	11/05/07	04/06/07	3.4
***Physocarpus* Diablo**	-	95 ± 0.9	87 ± 7.1	09/05/07	11/06/07	4.7
Pieris Carnival	-	96 ± 1.4	96 ± 0.9	05/06/07	17/09/07	14.9
Pittosporum Silver	-	31 ± 7.3	26 ± 6.2	12/10/07	15/01/08	13.6

Queen						
***Prunus cerasifera* Spring Glow**	-	45 ± 6.9	31 ± 1.3	09/05/07	11/06/07	4.7
Rhododendron Ginny Gee	-	82 ± 8.3	90 ± 4.1	19/07/07	05/11/07	15.6
Rosmarinus Miss Jessops	-	97 ± 1.0	99 ± 0.7	11/05/07	04/06/07	3.4
***Solanum crispum* Glasnevin**	-	98 ± 1.4	84 ± 1.5	09/05/07	04/06/07	3.7
***Spiraea* Arguta**	-	94 ± 1.0	65 ± 3.0	08/05/07	04/06/07	3.9
***Spiraea japonica* Goldflame**	-	100 ± 0.0	85 ± 3.8	08/05/07	04/06/07	3.9
***Spiraea nipponica* Snowmound**	-	96 ± 1.5	90 ± 1.6	08/05/07	11/06/07	4.9
Teucrium fruticans compactum	-	44 ± 7.6	29 ± 8.2	11/06/07	24/07/07	6.1
***Viburnum sargentii* Onondaga**	-	55 ± 7.1	34 ± 16.2	26/06/07	17/09/07	11.9
Mean	**-**	***77.6***	***73.8***			

Photo 7. Range of cutting subjects under Nobel / Evaposensor treatment plot 20 July 2007.

Photo 8. *Elaeagnus* Quicksilver under Timer treatment plot 20 July 2007, showing tray-to-tray variation in development.

Photo 9. Blueberry 'Chandler' 20/7/07 – Timer plot

Photo 10. Blueberry 'Chandler' 20/7/07 – Evaposensor / Nobel plot showed slightly better rooting than the Timer treatment.

In general, Evaposensor control has given as good, or slightly improved, rooting results in the first year compared to the Timer treatment. However, it must be remembered that the set-point used had to be a compromise for the wide range of subjects being propagated on the same bed. Also, the main objective of the first-year work at New Place Nursery was not to determine optimum environments for various cutting species, but to test the functioning of the Evaposensor and electronic interface / controllers in a commercial environment.

Where rooting was less good under the Evaposensor control, this was possibly due to over-wetting for that subject, although quite large variability of rooting from tray-to-tray might also suggest some variability in cutting quality or handling differences, or even spatial variation in the misting over the bed.

For the range of subjects being propagated at New Place Nurseries, a 1.0 – 1.5 °C WLD set point on the Evaposensor interface or controller appears to be a good starting point (using an approximate 2 second mist burst).

The primary function of the mist is to wet the cutting foliage and help minimise transpiration losses of water from the cutting by raising the vapour pressure deficit micro-climate around the stomata, as well as cooling the foliage. The mist also wets the rooting medium. Typically, sufficient water is supplied by the mist alone to maintain adequate moisture in the rooting medium, but depending partly on the type of standing base that cell trays are resting on, as well as the glasshouse aerial environment and mist scheduling, additional watering can sometimes be required in hot conditions.

At New Place Nurseries, the mist regime provided by both Timer and Evaposensor was sufficient and no additional watering was required on the treatments. Conversely, if a high degree of misting was required (e.g. to keep cutting foliage moist), surplus water could result in growing media to become saturated unless drainage was good. One would expect a sand bed base, as used at New Place, to provide ‘positive drainage’ by removing surplus water by capillary action. However, it is not clear whether the rooting media here was actually becoming saturated, and was partly responsible for some cuttings rotting, and if it *was* becoming over-wet whether this was because the sand bed was failing to draw out surplus water fast enough.

In Year 2, trials are continuing at New Place Nursery with a wide range of species under both Evaposensor and Timer mist control, and will enable further evaluation of the ETS interface unit against the Nobel controller. At Binsted and Lowaters Nurseries, just an ETS / Evaposensor treatment will be compared with the grower’s standard system (Heron controller at Lowaters and Priva irrigation computer with light integrator input at Binsted).

The Mk1 prototype ETS controller used at New Place Nursery has performed well and looks a promising alternative to the Nobel controller. Tests are continuing with this at New Place during Year 2 (2008/9), and the Mk 2 prototype installed at Binsted and Lowaters Nurseries also incorporates its own 24V AC power supply for the solenoid and mist burst length and interval timers allowing it to be used independently of any other controller (such as the Heron used at New Place), if required. Installation of Evaposensor control at New Place Nursery was fairly straightforward, and this flexibility of being able to fit the Evaposensor system to either run in conjunction with, or independently from, other controllers such as a Heron in an existing propagation facility is an important benefit.

Feedback about both Evaposensor control treatments from the manager and personnel involved with day to day running of the propagation unit at New Place Nursery has been positive. The automatic adjustment of mist with weather and light levels that is linked directly to the cuttings environment is seen as a great advantage, and it is accepted that manual adjustment of timer settings can never be as good. While, on average, the Evaposensor applied more mist to cuttings than their Timer settings, there were a number of periods, sometimes lasting for several days or weeks, with dull or cool weather when it applied less mist. The nursery accepts that different set points may be required for optimum results with different species, but growers can now trial these much more reliably by defining a WLD set point, which automatically takes account of the vagaries of weather changes and different ambient aerial environments between propagation units.

Growers wishing to start using Evaposensor mist control on their nurseries can obtain equipment from:

Evaposensor (specify PT100 type):

Skye Instruments Ltd
21 Ddole Enterprise Park
Llandrindod Wells
Powys LD1 6DF
Tel 01597 824811
www.skyeinstruments.com

ETS Evaposensor interface and controller:

Electronic & Technical Services Limited
106 Albion Street
Wallasey
Wirral
CH45 9JH
Tel 0151 639 4800
http://www.ets-controls.co.uk

For further technical advice on installation and use contact Chris Burgess or Richard Harrison-Murray via:

HDC Communications Manager
Scott Raffle
Horticultural Development Company
Bradbourne House
East Malling
Kent ME19 6DZ
Tel 01732 848383
www.hdc.org.uk

A production version of the ETS controller is expected to be available from September 2008. Further guidelines for getting the best results from this equipment will be produced following Year 2 of the project.