CONTRACT REPORT

INFLUENCE OF ENVIRONMENTAL FACTORS AND CROP MANAGEMENT ON THE INCIDENCE OF DISEASE ON LINERS OF OVERWINTERED HARDY NURSERY STOCK SPECIES

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EFFORD

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I declare that this work was done under my supervision according to the procedures described herein and that this report represents a true and accurate record of the results obtained.

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HDC HNS 49b

Influence of environmental factors and crop management on the incidence of disease on liners of overwintered hardy nursery stock species

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CONTENTS

GROWER RELEVANCE

Application

This three year Project has investigated the influence of relative humidity (RH) on the growth and incidence of disease on liners of various hardy nursery stock species in polythene tunnels during the winter period. Results have shown a major benefit from reducing RH to below 80% from January to April in terms of reducing downy mildew infection on *Hebe*. However, the economics of hiring/purchasing and running a dehumidifier may limit such an approach to growers of specialist crops (such as *Hebe*), where the development of diseases favoured by high RH's poses a particular problem.

Summary

The perception of an 'indoor' climate is determined mainly by two factors, temperature and humidity, both of which are important in terms of their influence on plant growth. Ambient air contains a certain amount of water vapour; as the temperature of the air decreases, its capacity to hold water vapour also decreases and water is precipitated out in the form of condensation. It is possible to remove water vapour from the air using dehumidification equipment.

Dehumidification can be achieved by two methods, condensation and sorption. Condensation occurs when air is cooled to a temperature below its dew point using compressor refrigeration. This process is used in refrigerative dehumidifiers, but it's efficiency is limited by temperature, being considerably reduced below (approximately) 10°C. In contrast, the sorption method of dehumidification involves the binding of moisture to a hygroscopic material, resulting in the release of latent heat and a rise in temperature. This process works with equal efficiency in all air conditions, including low temperatures.

High RH's are common in 'unheated' polythene tunnels during the winter period, especially in the 'wetter' areas of the UK, and condensation on the inside of the polythene is a common sight. These high RH's can present problems to growers of nursery stock liners by producing environments favourable for the infection and development of diseases such as *Botrytis* and downy mildews.

Work in the first year of this Project (1992/93) evaluated the effect of a number of potential stress factors (including RH, growing system, nutrition and growing media structure) on the growth of liners of *Choisya, Pieris* and *Rhododendron* in an attempt to determine the cause of the leaf distortion/scorching frequently reported by the industry. Although none of the treatments resulted in any abnormal foliar symptoms, plant growth was generally better in the 'low' (<80% RH) humidity regime (although this may have been due, at least in part, to the

slightly higher air temperatures resulting from the dehumidification process). A refrigerative dehumidifier was used for this first year's work, and difficulties encountered in achieving the target RH revealed the limitations of this type of dehumidifier at the low temperatures experienced in 'cold' polythene tunnels during the winter.

The influence of RH on the incidence of disease was investigated in some detail in 1993/94. Reduction of RH to below 80% significantly reduced the incidence of downy mildew and black spot on Rose 'Royal Worcester', and a similar trend was noted with downy mildew on *Hebe* 'Miss E Fittall'. Growing system also influenced the amount of disease recorded, with less disease present on plants grown on seephose irrigated sand beds, compared to those grown on overhead irrigated gravel beds. The use of a sorption dehumidifier proved successful in reducing RH to below 80% for most of the winter period.

In the final year of the Project (1994/95) the effect of RH coupled with plant spacing on the incidence of disease on liners of two cultivars of Rose, *Hebe* 'Autumn Glory' and *Lavandula angustifolia* 'Hidcote' was examined further. Very little *Botrytis* was recorded on any of the test species, but levels of downy mildew on *Hebe* were substantially lower where RH was reduced to below 80%, compared to the ambient and 'high' (RH>95%) regimes. The influence of plant spacing on the incidence of disease was much less marked than that of RH, and somewhat inconsistent, rendering wide spacings unacceptable from the point of view of cost, unless greater benefits (in terms of improved quality) can be demonstrated.

Spray programmes were deliberately delayed until diseases became obvious in order to determine the effectiveness of the RH treatments. This proved too late for achieving full control, highlighting the need to start spray applications early in the life of the crop in order to attain the best disease control.

The RH levels within several different sized polythene roof/net sided tunnels at HRI Efford were monitored by E A Technology Ltd, and were found to be very similar to those recorded in the small polythene clad tunnels used for the trial work. This is perhaps not surprising considering the naturally high RH's occurring at this time of the year. Condensation and moisture dripping onto the plants was less in the larger, side ventilated tunnels than in the small, fully enclosed tunnels. The specific influence of RH and/or free moisture (together with temperature) on the infection and spread of diseases such as the downy mildews and even *Botrytis* is largely unknown and further studies are required to identify critical thresholds.

The cost of hiring/purchasing a sorption dehumidifier together with the running costs may make dehumidification too expensive for consideration by all but specialist growers of disease prone species such as *Hebe*. Alternative methods of improving the environment within polythene tunnels, particularly by positive air movement, may be more cost effective and warrant further investigation.

Further information on dehumidification units can be obtained from Mr Chris Plackett, E A Technology Ltd, Farm Energy Centre, NAC, Stoneleigh, Kenilworth, Warwickshire CV8 2LS.

Action points

* The reduction of RH to below 80% has shown positive benefits in terms of improved plant quality and reduction in levels of diseases favoured by high humidity.

* The use of 'wide' spacings could be considered for species where diseases pose a major problem, although this is less effective than reducing RH and may not be cost effective.

* The work carried out in this Project has highlighted the need to combine good cultural management (such as growing on low level irrigated sand beds rather than overhead irrigated gravel beds) with effective protectant spray programmes started early in the life of the crop, in order to produce top quality plants.

* Alternative methods of improving the environment within polythene tunnels, particularly by positive air movement warrant further investigation, as potentially cost effective alternatives to dehumidification.

* More work is needed to determine the levels of RH and/or free moisture required for the infection and spread of specific pathogens so that environments can be manipulated to minimize the incidence of these diseases.

INTRODUCTION

A large proportion of nursery stock liners are grown 'cold' in polythene tunnels, with only sufficient heat to provide frost protection over the winter period. Ventilation is frequently minimal, and high humidities often prevail, favouring the development of diseases such as downy mildews and *Botrytis*. Growing systems within the polythene tunnel may also affect the incidence of disease (and weeds, including moss and liverwort) as well as overall plant quality. Drained sand beds watered by seephose to provide capillary irrigation generally produce a better quality plant than overhead irrigated gravel beds.

Work in the first year of this Project (1992/93) evaluated the effect of a number of potential stress factors on plant growth, in an attempt to determine the cause of the leaf distortion/ scorching frequently reported by the industry on liners of certain evergreen species such as *Choisya*, *Pieris* and *Rhododendron*. Relative humidity, growing system, nutrition and growing media structure were investigated, but none of the treatments resulted in any abnormal foliar symptoms. However, plant growth was generally better in the 'low' humidity regime, (although this may have been due, at least in part, to the slightly higher air temperature resulting from the dehumidification process in this trial), and the incidence of weeds, particularly liverwort, was less widespread. A refrigerative dehumidifier was used for this first year's work, and problems were encountered in reducing RH to below 80% at the relatively low temperatures recorded during the winter period.

In 1993/94 the effect of 3 different relative humidity (RH) regimes - 'low' (<80%), ambient and 'high' (>90%) - on the incidence of disease (during the winter/spring period) on newly potted liners of *Cistus, Hebe, Rhododendron* and Rose was evaluated. Reduction of RH to <80% significantly reduced the incidence of downy mildew *(Peronospora sparsa)*, and black spot *(Diplocarpon rosae)* on Rose 'Royal Worcester'. A similar trend was noted with downy mildew *(Peronospora grisea)* on *Hebe* 'Miss E Fittall'.

In contrast to the downy mildews, powdery mildews prefer drier conditions, and powdery mildew (*Oidium* spp) became obvious on *Rhododendron* plants towards the end of the trial, particularly in the 'low' humidity tunnel when temperatures increased from May onwards. However, in a commercial situation plants would have sold/'potted on' before this became a problem.

With increasing pressure to reduce the use of pesticides, and the decreasing number of chemicals available, manipulation of environmental conditions may offer an alternative method of controlling some of these diseases, and possibly even weed growth especially moss and liverwort, if it is economically viable.

Aspects of husbandry, for example plant spacing, may also affect the incidence/spread of disease due to a change in microclimate around individual plants (this was demonstrated in work carried out by Dr Tim O'Neill on container grown roses out of doors (Project HNS53) where the incidence and severity of downy mildew *(Peronospora sparsa)* was reduced as spacing increased). Consequently, an investigation of the influence of plant spacing and RH on the incidence of disease formed the basis of the experimental work in this project in the final year (1994/95).

Although the 3 small, single span polythene tunnels used for the 3 year's work are ideal for experimental work, they are not typical of those used by the industry. The RH's in larger, and especially taller, tunnels may to be different to those in these small experimental tunnels, depending on the length, height and number of spans. Therefore the RH levels in 2 different types/sizes of tunnels were recorded by E A Technology Ltd in order to determine the economic feasibility of dehumidification in these larger structures.

OBJECTIVES

a) To investigate the effect of different humidity regimes and 3 pot spacings on the incidence of disease (during the winter period) on newly potted liners of several HNS species.

b) To monitor levels of RH occurring within commercial scale polytunnels, and to determine whether the use of a sorption dehumidifier provides an energy efficient, cost effective method of controlling relative humidity.

Note: For ease of interpretation the report has been divided into two sections, the first dealing with the experimental work carried out at HRI Efford (objective a)) and the second with the RH measurement within larger tunnel structures by E A Technology Ltd (objective b)).

EXPERIMENTAL SECTION

PART 1: EVALUATION OF RH AND POT SPACING ON INCIDENCE OF DISEASE

MATERIALS AND METHODS

Treatments

1. Target RH's

a) maximum of 80%, achieved by using a Munters M300 sorption dehumidifier (supplied by E A Technology Ltd).

b) ambient.

c) minimum of 95%, achieved by using a CF-2 fogging system (Duntech Irrigation Services Ltd).

Three single span tunnels (11m long x 4.25m wide) were used, with one humidity treatment in each tunnel.

2. Pot spacing

a) pot thick (plant centres at 9 cm).

b) 1.5 cm between pots (plant centres at 10.5 cm).

c) 3 cm between pots (plant centres at 12 cm).

3. Species

Rose 'Magic Carousel'
Rose 'Scarlet Pimpernel'
Lavandula angustifolia 'Hidcote'
Hebe 'Autumn Glory'

4. Chemical control of diseases *(Note: spray programmes were commenced only when disease symptoms became obvious)*

Hebe: (for control of downy mildew)	a)	fosetyl-aluminium as Aliette applied as a foliar spray at 14 day intervals at 0.15g commercial product in 40ml water/m² (5 sprays applied, commencing 29 March 1995)
	b)	no Aliette applied.
Lavandula, Rose and *Hebe* :(for control of *Botrytis*)	a)	iprodione as Rovral applied as a foliar spray at 14 day intervals at 1g commercial product/litre (6 sprays applied, commencing 13 January 1995)
	b)	no Rovral applied

Experimental design

Split plot design with the main treatments (humidity regimes) not replicated. The sub-plot treatments (spacing) had 6 replicates of each species and 6 recorded plants/replicate. When diseases became apparent 3 of the 6 replicates received the fungicide programmes and 3 were not sprayed. Each plot had a surrounding row of guard plants of the same treatment.

Trial site

The three small tunnels (orientated east-west) were fully clad in polythene.

The northern tunnel contained the CF-2 fogging system, and the southern the M300 dehumidifier. The centre tunnel was the ambient humidity 'control'.

Husbandry

Each tunnel contained two sand beds each with seephose irrigation.

Rooted cuttings of *Hebe* and micropropagated plug plants of Rose and Lavender were potted in mid November 1994. All plants were potted into round 9 cm pots using Shamrock peat with 1.5 kg/m^3 magnesian limestone, 3.5 kg/m^3 Osmocote Plus Autumn 15+8+11+2 MgO plus traces, and 750 g/m^3 suSCon Green.

After potting, plants were kept in a glasshouse (heated to provide frost protection only) for 2-3 weeks prior to moving to the three treatment tunnels in early December 1994.

Two 2.8kW Hotbox fan heaters were installed in the ambient and 'high' humidity tunnels and set to provide sufficient heat for frost protection only.

Hebe plants were stopped in early February 1995 to encourage a flush of new growth on which to make an assessment of disease part way through the season. After an assessment in mid April diseased shoots were cut out and a final assessment of plant vigour made at the end of the trial.

In early April, plants of both cultivars of Rose were cut back to approximately 10 cm to encourage lateral shoot development.

Three sprays of pirimicarb as Pirimor were applied throughout the trial period to control aphid.

Assessments

Environmental records

The air temperature (°C) and relative humidity (%) were recorded at 30 minute intervals in each humidity regime throughout the trial period using a Delta T data logger.

Irrigation water applied

The quantity of water (in litres) applied was recorded (using a Kent water meter) throughout the trial period.

Plant Growth Records

1. Rose 'Magic Carousel' and 'Scarlet Pimpernel'

The following records were taken on 1 June 1995.

a) Number of dead plants.

b) Plant height (cm).

c) Number of primary branches/plant.

d) Number of secondary branches/plant.

e) An assessment of powdery mildew (*Sphaerotheca pannosa*) infection was made using a scale of 0-3, where 0 = no infection, 1 = slight infection, 2 = moderate infection and 3 = severe infection.

f) Finally an assessment of marketability was made based on plant size and level of disease infection.

2. *Lavandula angustifolia* 'Hidcote'

The following records were taken on 17 June 1995.

a) Number of dead plants.

b) Number of live shoots/plant.

c) Number of dead shoots/plant.

d) Number of flower spikes/plant.

e) An assessment of plant vigour was made using a 1-5 score where 1 = least vigorous and 5 = most vigorous (Plate 1, page 35).

f) A record of rooting through the bottom of the pot was also made using a score of 0-3 where 0 = no roots visible and 3 = many roots emerging through base of pot (Plate 2, page 35).

3. *Hebe* 'Autumn Glory'

A score of downy mildew infection was made on 18 April 1995 using a 0 - 4 scale:

0 = no infection

1 = 1 or 2 shoots infected, plants generally large and growing vigorously

2 = 2-4 shoots infected, plants of good size and growing vigorously

3 = all but one or two shoots infected, plants generally small

4 = virtually all shoots infected, with no shoots growing vigorously, plants small.

The following records were taken on 1 July 1995.

a) Number of dead plants.

b) An assessment of plant vigour was made using 1 - 6 score where 1 = least vigorous and 6 = most vigorous (Plate 3, page 36).

RESULTS

1. Environmental records

The average temperature, RH and number of hours above 80% RH are shown for typical weeks in February, March and April in Table 1 (page 12).

Average temperatures in the 'low' humidity tunnel were slightly higher (0.5-1^{0}C) than those in the 'ambient' and 'high' humidity tunnels throughout most of the trial period.

Throughout February, RH remained high in the 'ambient' tunnel and under these conditions the dehumidification unit only succeeded in reducing the RH in the 'low' humidity to an average of 85% RH, with an RH of <80% being achieved for only one third of the time. However, better control of RH was achieved in March and April when ambient RH's were lower.

Very little condensation was seen on the inside of the polythene cover in the 'low' humidity tunnel. In contrast, in the 'ambient' and more especially the 'high' humidity regimes, the polythene was covered in condensation for much of the time, with droplets of moisture falling onto the crops periodically.

A summary of temperature and RH levels is shown graphically in Appendix III, pages 30 and 31.

Table 1: Average temperature (^{0}C), average RH (%) and number of hours of > 80% RH for weekly periods in February, March and April 1995 in the 3 test humidity regimes

Date		'Low' humidity regime			'Ambient' humidity regime			'High' humidity regime		
		Average temp^{0}C	Average % RH	Hours > 80% RH	Average temp^{0}C	Average % RH	Hours > 80% RH	Average temp^{0}C	Average % RH	Hours > 80% RH
February	7	11.5	86.6	17.5	10.6	93.9	24.0	10.4	99.1	24.0
	8	12.1	82.9	16.0	11.2	91.2	22.0	10.8	98.0	24.0
	9	8.0	82.3	14.0	7.3	95.6	24.0	7.1	99.8	24.0
	10	11.0	83.1	16.5	10.4	90.7	21.5	10.1	96.5	23.0
	11	10.1	90.4	21.5	9.4	95.7	24.0	9.3	100.0	24.0
	12	10.4	88.1	16.5	11.1	83.9	17.0	11.0	89.9	18.0
	13	10.9	89.2	19.5	10.6	91.3	21.0	10.2	97.9	24.0
	14	10.5	87.5	18.0	10.9	86.5	18.5	10.6	93.0	20.5
March	7	7.1	65.6	4.5	6.1	91.5	24.0	6.2	98.0	24.0
	8	10.8	60.0	6.5	10.1	76.8	14.5	9.6	85.5	16.0
	9	10.6	56.2	2.0	10.0	83.2	16.0	9.4	93.7	21.5
	10	14.1	50.7	0.5	12.5	78.3	14.5	11.9	84.8	17.0
	11	13.8	32.3	0.0	12.0	84.8	18.5	11.5	92.8	20.0
	12	13.4	52.1	3.5	12.3	77.3	15.5	12.1	82.2	16.5
	13	10.1	71.2	13.5	10.8	72.6	14.0	10.2	79.0	14.5
	14	10.3	66.4	8.0	9.6	83.8	18.0	9.2	90.5	19.5
April	7	16.5	62.4	7.0	15.3	77.2	15.0	15.3	82.5	17.5
	8	12.8	70.3	12.0	13.3	69.2	12.0	12.5	75.2	13.5
	9	12.6	70.3	12.5	12.6	72.5	13.0	13.2	77.8	15.0
	10	15.4	64.5	8.5	14.3	78.5	15.0	13.8	86.4	18.5
	11	14.8	60.2	6.5	15.3	68.7	13.0	14.3	75.4	14.0
	12	16.1	53.6	6.0	16.0	66.9	13.0	15.3	71.9	13.5
	13	13.2	72.5	12.5	13.9	68.2	12.5	13.1	73.4	12.5
	14	14.6	69.5	11.5	14.7	73.5	14.5	14.0	80.3	16.5

2. Irrigation water applied

Routine irrigation was applied to the sand through seephose tubing, but 'spot' watering of localised dry areas of pots along the edges of the sand beds was necessary in all tunnels, especially in the 'low' humidity regime.

Table 2: Quantity of water applied (litres) through seephose tubing from January-May 1995 according to humidity regime

	Humidity regime		
Month (1995)	**'low'**	**'ambient'**	**'high'**
January	nil	nil	nil
February	917	248	nil
March	1977	2386	nil
April	3826	3428	2444
May	1106	1249	1121
TOTAL	7826	7311	3565

In the 'high' humidity tunnel the fogging equipment produced enough moisture to keep the plants sufficiently moist throughout January, February and March, without the need for any irrigation. The 'low' humidity regime required, on average, 10% more water than the 'ambient' tunnel.

3. Plant growth records and disease assessments

Note: Due to the variability of the results, no statistical analysis of data was undertaken

Rose 'Magic Carousel' (Appendix II, Table 5, page 25)

Overall, plant quality of this cultivar was generally poor, irrespective of treatment and this was reflected in the number of marketable plants. Neither spacing or humidity regime had any obvious effect on plant height, or the number of branches/plant.

Very little ***Botrytis*** was seen on plants in any of the treatments including the unsprayed plots. No **downy mildew** was seen throughout the trial period.

A slight infection of **powdery mildew** became established in the 'low' humidity regime in late May, although this did not significantly reduce marketability.

As was to be expected, more plants in unsprayed plots were recorded with a slight infection of powdery mildew than in the sprayed plots. Here a clear effect of plant spacing on disease levels was manifest, with the wider spaced plants having less disease than those grown pot thick.

More deaths were recorded in the 'high' humidity tunnel compared to the 'ambient' and 'low' humidity regimes.

Rose 'Scarlet Pimpernel' (Appendix II, Table 6, p26)

Plants in the 'low' humidity regime were slightly shorter, with fewer secondary branches than those in the other 2 tunnels.

As with 'Magic Carousel' no ***Botrytis*** or **downy mildew** was recorded but plant quality in the 'low' humidity tunnel was severely affected by **powdery mildew** which came in on both sprayed and unsprayed plots towards the end of the trial. In the 'ambient' humidity regime a slight infection was becoming established, but a high proportion of the plants were still marketable. No disease was recorded in the 'high' humidity tunnel.

Spacing had little consistent effect on the incidence of disease or on plant quality.

Lavandula angustifolia **'Hidcote'** (Appendix II, Table 7, p27)

No ***Botrytis*** was found on any of the plants, although dead shoots were recorded on most plants. Further investigation is required to determine whether this shoot death (which occurs on plants of all ages, especially in 'wet' conditions) is caused by a pathogen or is a physiological disorder.

Humidity regime, spray programme and pot spacing appeared to have no consistent effect on plant growth, although some trends could be identified in the 'low' humidity tunnel. Here, more flower spikes were recorded at the widest spacing. An apparent increase in shoot numbers on the sprayed plants in the 'low' humidity regime needs confirmation as results were variable.

Hebe **'Autumn Glory'** (Appendix II, Tables 8 & 9, pp28 + 29)

An early slight infection of ***Botrytis*** was readily controlled by an overall spray of Rovral. The spray programme of Rovral was continued on 'sprayed' plots but infection did not recur even on unsprayed plants. However unusual 'dieback' symptoms producing short 'pineapple spikes' of small leaves, initially thought to be ***Botrytis*** was later identified as **downy mildew**, and a spray programme of Aliette was commenced. These infected shoots were cut out after an assessment on 18 April.

A summary of the assessment of downy mildew carried out on 18 April presented in Table 3 shows the overriding influence of RH on the incidence of this disease, with severity increasing with RH.

There was also evidence of an effect of plant spacing on disease, with less disease at the wider spacing.

The combined effect of RH (in particular) and plant spacing had more influence on disease levels than the applied spray programme.

By early July levels of disease were reflected in plant vigour, with the most vigorous plants recorded in the 'low' humidity regime and the least vigorous in the 'high' humidity tunnel.

Table 3: ***Hebe*** **'Autumn Glory': Summary of downy mildew infection, recorded 18 April 1995**

	% plants with downy mildew score 0-2 (ie. plants still marketable)			
	Plant centres			
Humidity regime	**9 cm**	**10.5 cm**	**12 cm**	**Mean**
Sprayed				
'Low'	78	67	61	69
'Ambient'	17	44	61	41
'High'	12	22	44	26
Mean	36	44	55	
Not sprayed				
'Low'	66	89	83	79
'Ambient'	12	44	23	26
'High'	0	5	17	7
Mean	26	46	41	

PART 2: MONITORING OF RH AND TEMPERATURE IN POLY TUNNELS

MATERIALS & METHODS

Temperature and RH were measured in the following structures (in addition to the 3 trial tunnels) by E A Technology Ltd:

a) a single span polythene tunnel
5.5m wide, 19.7m long and 2.8m high, with a netting skirt to a height of 1m

b) a triple span tunnel
19.3m wide, 14.0m long and 3.8m high, with straight sides (2.4m to gutter) and netting from gutter to 1m above ground level, where it met a polythene skirt.

Both of these tunnels were unheated, and contained crops of HNS subjects in 2/3 litre pots.

External ambient temperature and RH were also measured.

RESULTS

The average temperature and %RH are shown for typical weeks in January, February and March 1995 in Table 4 and graphically from late December 1994 to mid May 1995 in Appendix III, pages 32-34. Although the single span, triple span and trial tunnel were very different in size and specification the %RH was very similar during the winter period when outdoor ambient RH's were high. Less condensation was seen on the inside of the polythene in the larger structures with side ventilation, compared to the 'ambient' trial tunnel (which received heating to give 'frost protection').

Table 4: **Summary of RH and temperature in 2 sizes of polythene tunnel, external ambient and 'ambient' trial tunnel**

Date (1995)		External ambient		Single span tunnel With net sides		Triplespan tunnel With net sides		Trial tunnel 'ambient' (No net sides)	
		Average temp ^{0}C	Average % RH	Average temp^{0}C	Average % RH	Average temp ^{0}C	Average % RH	Average temp ^{0}C	Average %RH
January	7	4.5	97.2	4.7	93.8	4.7	92.4		
	8	7.4	96.5	7.1	94.5	7.0	93.8		
	9	7.1	92.4	6.8	88.3	6.7	89.2		
	10	9.9	92.2	9.8	87.9	9.5	88.4		
	11	4.3	88.9	4.4	88.1	4.6	84.5		
	12	1.3	86.7	1.7	80.3	1.7	79.8		
	13	5.0	92.5	5.4	85.9	5.5	85.2		
February	7	9.4	99.7	9.4	91.4	9.5	90.8	10.6	93.9
	8	8.2	100.0	8.8	93.9	9.0	92.3	11.2	91.2
	9	5.4	100.0	5.5	92.2	5.7	91.7	7.3	95.6
	10	9.0	99.8	9.1	93.7	9.1	92.2	10.4	90.7
	11	8.9	100.0	8.8	96.2	8.7	95.5	9.4	95.7
	12	9.2	99.1	9.7	85.9	9.3	86.2	11.1	83.9
	13	8.6	99.8	8.7	92.8	8.7	91.6	10.6	91.3
March	7	4.2	80.8	4.3	87.4	4.5	85.4	6.1	91.5
	8	4.9	77.5	4.7	77.7	5.7	74.5	10.1	76.8
	9	5.9	75.3	5.6	81.4	6.0	78.2	10.0	83.2
	10	9.5	71.2	9.1	78.8	10.0	72.1	12.5	78.3
	11	9.7	82.3	9.9	86.7	10.3	83.2	12.0	84.8
	12	9.4	96.0	8.2	77.7	9.5	71.7	12.3	77.3
	13	8.6	74.0	6.6	76.4	8.0	72.1	10.8	72.6

DISCUSSION

The trial undertaken in 1994/95 constituted the final year of work in a 3 year Project evaluating the influence of RH on plant growth and in particular on the incidence of disease, and the potential benefits of dehumidification in 'cold' polythene tunnels during the winter period. Since diseases such as *Botrytis* and downy mildew are favoured by high RH's, spacing the crop was investigated as a way of increasing air movement around the plants and so improving the microclimate at crop level. The main objectives of this year's work were to determine the effect of RH and plant spacing on disease levels of Rose 'Magic Carousel', 'Scarlet Pimpernel', *Lavandula angustifolia* 'Hidcote' and *Hebe* 'Autumn Glory'.

Some mechanical problems were encountered with the sorption dehumidifier during the early weeks of the trial. Thereafter, although the minimum target RH of 80% was not achieved until the later part of the trial, the number of hours above 80% RH was less than in the 'ambient' tunnel. This failure to adequately reduce RH may have been due to the high external RH's during the early part of the year, and/or insufficient capacity of the machine to meet the demands made upon it.

Botrytis did not prove to be a problem in any of the humidity regimes, even on unsprayed plots.

Downy mildew was the most prevalent disease on *Hebe* 'Autumn Glory', with RH having a major effect on its incidence. As in last year's trial much less disease was recorded on plants in the 'low' humidity tunnel than in the 'ambient' and especially the 'high' humidity regimes. Levels of this disease were affected to a much lesser extent than expected by plant spacing and although somewhat less disease occurred at the wider spacings the loss of production at the wider spacing would make such spacings uneconomic. At the closest spacing (i.e. pot thick) 121 plants could be accommodated in 1 square meter, compared to almost half this number at the widest spacing, with 3cm between pots. The economic implications of this are obvious and a more significant reduction in the incidence of disease and/or improvement in plant quality would be required to offset the additional space required to accommodate these wider spacings.

Spray programme appeared to be of minimal importance once downy mildew had become established, highlighting the need to apply the first sprays early in the season to protect the crop from infection. However, for the purposes of determining the effect of RH on disease incidence, the commencement of the spray programme was deliberately delayed until disease symptoms became established. Previous HDC funded work (HO/21) carried out at HRI Efford had shown Aliette to give the best control of downy mildew on *Hebe* but results in the trial were disappointing, probably due to the later start of the spray programme. Although Aliette was used throughout the trial period, repeated use of the same chemical should be avoided in a commercial situation to avoid the likelihood of resistance build up.

Although powdery mildew was becoming obvious on roses in the 'low' humidity tunnel towards the end of the trial, this disease can readily be controlled by an appropriate spray programme and plants would normally have been sold before disease levels became significant.

No *Botrytis* was found on any of the Lavender plants, but shoot death did occur in all humidity regimes. This may have been due to a physiological disorder which is not yet fully understood, but which occurs frequently on plants of all ages, or due to another pathogen. Further work is required to determine the cause of this widespread problem.

The RH levels monitored in a 19.7m long x 5.5m wide single span tunnel with a netting skirt, and a 14m long x 19.3m wide triple span tunnel with side ventilation were very similar to those recorded in the small 'ambient' trial tunnel. External RH's were high during this period and were similarly high in all tunnels regardless of size and ventilation.

More condensation was visible on the interior of the polythene cover of the small 'ambient' tunnel than on the covers of the larger side ventilated structures. In such situations droplets of moisture often fall onto the foliage of the crop resulting in leaf wetting, providing potential sites of infection for diseases requiring free surface moisture for spore germination. Little information is available on the optimal temperature and RH requirements for infection and development of specific diseases, and it is therefore currently difficult to identify the best environmental conditions for disease 'avoidance'.

The cost of dehumidification is likely to be warranted only for growers of 'specialist' crops such as *Hebe* which are prone to infection by diseases favoured by high humidities. However, this Project has demonstrated the relative influences of RH, growing system (sand beds with low level irrigation) and plant spacing together with timely spray programmes on the incidence of diseases such as downy mildew, with the 'drier' systems being less favourable for the development of these diseases. Other methods of 'improving' the environment such as positive air movement warrant investigation, as potentially cheaper alternatives to dehumidification.

CONCLUSIONS

* Very little if any *Botrytis* occurred during the course of this work, making an assessment of the effects of dehumidification on this disease impossible.

* RH exerted a major influence on the incidence of downy mildew on *Hebe*, with lower humidities resulting in less disease.

* Plant spacing also affected disease levels on *Hebe*, although to a much lesser extent than RH, with more disease at the closest spacing. However, the financial implications of wider plant spacings must be considered in view of the limited benefits achieved.

* The spray programme for the control of downy mildew in the trial was not effective, probably due to the delayed application of the first sprays. (Disease was allowed to establish in order to monitor the influence of RH as a 'control measure'.)

* There was surprisingly little difference in the RH's measured in 3 tunnels of different sizes and specification, although external ambient RH was high during much of the trial period.

* Dehumidification may only be cost effective on specialist crops such as *Hebe*, where high RH's favour the development of the diseases such as downy mildew

* Powdery mildew began to develop on the roses late in the trial in the dehumidified tunnel. This would not normally be a problem since crops would have been sold before then.

RECOMMENDATIONS FOR FURTHER WORK

* More work is needed to investigate the effects of positive air movement within poly tunnels on disease levels and plant quality.

* Information is also needed on the optimal conditions for infection and development of diseases such as *Botrytis* and downy mildew so that environmental conditions can be manipulated to minimize the likelihood of incidence.

ACKNOWLEDGEMENTS

Grateful thanks are due to Tim Pratt and Chris Plackett from E A Technology Ltd for their help in monitoring temperature and RH, for supplying the dehumidifier and for the graphical presentation of environmental data.

APPENDIX I

LAYOUT OF PLOTS OF TREATMENT SPACINGS IN 'LOW' HUMIDITY TUNNEL

Cultivar	Rep			Rep
ROSE 'SCARLET PIMPERNEL'	Rep IV	10.5cm	10.5cm	Rep I
		12cm	9cm	
		9cm	12cm	
	Rep V	9cm	12cm	Rep II
		12cm	10.5cm	
		10.5cm	9cm	
	Rep VI	9cm	9cm	Rep III
		10.5cm	12cm	
		12cm	10.5cm	
ROSE 'MAGIC CAROUSEL'	Rep IV	9cm	9cm	Rep I
		10.5cm	10.5cm	
		12cm	12cm	
	Rep V	9cm	9cm	Rep II
		10.5cm	12cm	
		12cm	10.5cm	
	Rep VI	12cm	10.5cm	Rep III
		10.5cm	12cm	
		9cm	9cm	

Rep			Rep	Cultivar
Rep IV	9cm	10.5cm	Rep I	*HEBE* 'AUTUMN GLORY'
	12cm	9cm		
	10.5cm	12cm		
Rep V	12cm	12cm	Rep II	
	10.5cm	10.5cm		
	9cm	9cm		
Rep VI	9cm	10.5cm	Rep III	
	10.5cm	9cm		
	12cm	12cm		
Rep IV	10.5cm	12cm	Rep I	*LAVANDULA ANGUSTIFOLIA* 'HIDCOTE'
	9cm	9cm		
	12cm	10.5cm		
Rep V	10.5cm	12cm	Rep II	
	9cm	10.5cm		
	12cm	9cm		
Rep VI	9cm	9cm	Rep III	
	12cm	10.5cm		
	10.5cm	12cm		

Sprayed replicates

Rose 'Magic Carousel':	III, IV & V
Rose 'Scarlet Pimpernel':	I, III & V
Hebe 'Autumn Glory':	II, IV & VI
Lavandula angustifolia 'Hidcote':	I, V & VI

APPENDIX I

LAYOUT OF PLOTS OF TREATMENT SPACINGS IN 'AMBIENT' HUMIDITY TUNNEL

ROSE 'SCARLET PIMPERNEL'	Rep IV	10.5cm	9cm	Rep I
		9cm	12cm	
		12cm	10.5cm	
	Rep V	10.5cm	10.5cm	Rep II
		9cm	12cm	
		12cm	9cm	
	Rep VI	12cm	12cm	Rep III
		9cm	10.5cm	
		10.5cm	9cm	
ROSE 'MAGIC CAROUSEL'	Rep IV	10.5cm	10.5cm	Rep I
		12cm	12cm	
		9cm	9cm	
	Rep V	10.5cm	9cm	Rep II
		12cm	10.5cm	
		9cm	12cm	
	Rep VI	10.5cm	12cm	Rep III
		9cm	10.5cm	
		12cm	9cm	

HEBE 'AUTUMN GLORY'	Rep IV	9cm	9cm	Rep I
		10.5cm	10.5cm	
		12cm	12cm	
	Rep V	12cm	9cm	Rep II
		9cm	12cm	
		10.5cm	10.5cm	
	Rep VI	10.5cm	9cm	Rep III
		12cm	12cm	
		9cm	10.5cm	
LAVANDULA ANGUSTIFOLIA 'HIDCOTE'	Rep IV	9cm	9cm	Rep I
		12cm	12cm	
		10.5cm	10.5cm	
	Rep V	12cm	10.5cm	Rep II
		10.5cm	9cm	
		9cm	12cm	
	Rep VI	10.5cm	10.5cm	Rep III
		9cm	9cm	
		12cm	12cm	

Sprayed replicates

Rose 'Magic Carousel':	III, IV & V
Rose 'Scarlet Pimpernel':	II, III & IV
Hebe 'Autumn Glory':	I, III & V
Lavandula angustifolia 'Hidcote':	I,II & VI

APPENDIX I

LAYOUT OF PLOTS OF TREATMENT SPACINGS IN 'HIGH' HUMIDITY TUNNEL

Cultivar	Rep			Rep
ROSE 'SCARLET PIMPERNEL'	Rep IV	12cm	9cm	Rep I
		9cm	12cm	
		10.5cm	10.5cm	
	Rep V	9cm	10.5cm	Rep II
		10.5cm	12cm	
		12cm	9cm	
	Rep VI	9cm	9cm	Rep III
		10.5cm	12cm	
		12cm	10.5cm	
ROSE 'MAGIC CAROUSEL'	Rep IV	9cm	9cm	Rep I
		12cm	10.5cm	
		10.5cm	12cm	
	Rep V	9cm	9cm	Rep II
		10.5cm	12cm	
		12cm	10.5cm	
	Rep VI	10.5cm	10.5cm	Rep III
		12cm	9cm	
		9cm	12cm	

Rep			Rep	Cultivar
Rep IV	10.5cm	9cm	Rep I	*HEBE* 'AUTUMN GLORY'
	12cm	12cm		
	9cm	10.5cm		
Rep V	10.5cm	12cm	Rep II	
	12cm	9cm		
	9cm	10.5cm		
Rep VI	12cm	10.5cm	Rep III	
	10.5cm	9cm		
	9cm	12cm		
Rep IV	12cm	9cm	Rep I	*LAVANDULA ANGUSTIFOLIA* 'HIDCOTE'
	9cm	12cm		
	10.5m	10.5cm		
Rep V	9cm	9cm	Rep II	
	10.5cm	10.5cm		
	12cm	12cm		
Rep VI	9cm	10.5cm	Rep III	
	12cm	12cm		
	10.5cm	9cm		

Sprayed replicates

Rose 'Magic Carousel':	II, III & IV
Rose 'Scarlet Pimpernel':	I, II & VI
Hebe 'Autumn Glory':	I, V & VI
Lavandula angustifolia 'Hidcote':	III, IV & V

APPENDIX II

Table 5: Rose 'Magic Carousel': summary of growth records and disease assessment, recorded 1 June 1995

Humidity regime and plant centres		% mkt plants	% dead plants	Mean plant height (cm)	Mean number of branches/plant Primary	Secondary	% plants with powdery mildew score 0 (nil)	1	2	3 (severe)
Sprayed										
'Low'	9 cm	56%	0%	25.0	2.5	4.7	78%	22%	0%	0%
	10.5 cm	44%	0%	21.9	2.0	3.6	83%	17%	0%	0%
	12 cm	33%	0%	24.3	2.0	3.8	78%	22%	0%	0%
'Ambient'	9 cm	50%	0%	21.8	1.9	3.4	100%	0%	0%	0%
	10.5 cm	50%	0%	23.3	1.6	3.9	100%	0%	0%	0%
	12 cm	33%	0%	22.9	1.8	3.2	100%	0%	0%	0%
'High'	9 cm	17%	12%	20.9	2.3	4.2	88%	0%	0%	0%
	10.5 cm	22%	34%	20.6	2.4	3.7	66%	0%	0%	0%
	12 cm	61%	12%	21.4	2.4	4.4	88%	0%	0%	0%
Not Sprayed										
'Low'	9 cm	34%	6%	23.4	2.2	4.4	39%	55%	0%	0%
	10.5 cm	56%	6%	20.9	2.2	3.8	61%	33%	0%	0%
	12 cm	45%	12%	21.7	1.9	3.8	83%	5%	0%	0%
'Ambient'	9 cm	55%	0%	21.0	2.2	4.1	100%	0%	0%	0%
	10.5 cm	83%	0%	24.8	1.8	4.2	100%	0%	0%	0%
	12 cm	55%	0%	22.2	2.0	3.9	100%	0%	0%	0%
'High'	9 cm	44%	6%	25.2	2.5	5.3	94%	0%	0%	0%
	10.5 cm	33%	17%	22.1	2.5	4.1	83%	0%	0%	0%
	12 cm	67%	6%	23.2	2.7	4.7	94%	0%	0%	0%

Powdery mildew score
0 = nil
1 = slight
2 = moderate
3 = severe

APPENDIX II

Table 6: Rose 'Scarlet Pimpernel': summary of growth records and disease assessment, recorded 1 June 1995

Humidity regime and plant centres	% mkt plants	% dead plants	Mean plant height (cm)	Mean number of branches/plant: Primary	Mean number of branches/plant: Secondary	% plants with powdery mildew score: 0 (nil)	1	2	3 (severe)
Sprayed									
'Low' 9 cm	11%	0%	21.2	3.0	4.0	6%	39%	55%	0%
10.5 cm	6%	0%	21.1	3.7	3.3	11%	33%	56%	0%
12 cm	0%	0%	20.7	3.2	4.4	0%	0%	100%	0%
'Ambient' 9 cm	72%	0%	22.3	2.6	4.3	83%	17%	0%	0%
10.5 cm	78%	0%	22.1	3.2	4.9	100%	0%	0%	0%
12 cm	89%	0%	22.9	2.5	5.7	94%	6%	0%	0%
'High' 9 cm	83%	0%	25.1	2.6	6.8	100%	0%	0%	0%
10.5 cm	94%	0%	22.7	2.9	5.8	100%	0%	0%	0%
12 cm	83%	0%	23.5	2.4	6.5	100%	0%	0%	0%
Not Sprayed									
'Low' 9 cm	0%	0%	20.9	3.4	3.7	0%	45%	55%	0%
10.5 cm	6%	0%	21.3	2.7	3.1	6%	0%	94%	0%
12 cm	0%	0%	21.3	3.8	3.3	6%	0%	94%	0%
'Ambient' 9 cm	78%	0%	24.2	2.4	5.4	72%	28%	0%	0%
10.5 cm	94%	0%	23.3	2.8	5.9	100%	0%	0%	0%
12 cm	89%	0%	22.3	3.3	4.7	45%	55%	0%	0%
'High' 9 cm	100%	0%	26.8	3.1	5.9	100%	0%	0%	0%
10.5 cm	78%	0%	24.3	3.6	5.5	100%	0%	0%	0%
12 cm	72%	0%	22.7	2.8	6.7	100%	0%	0%	0%

Powdery mildew score
0 = nil
1 = slight
2 = moderate
3 = severe

APPENDIX II

Table 7: *Lavandula angustifolia* 'Hidcote': summary of growth scores, recorded 17 June 1995

Humidity regime and plant centres	% plants with vigour score (5 = most vigorous) 1	2	3	4	5	% dead plants	Mean root score	Mean no. shoots/plant alive	dead	Mean no. flower spikes/plant
Sprayed										
'Low' 9 cm	6%	16%	50%	6%	16%	6%	2.3	8.2	1.4	4.9
10.5 cm	0%	17%	33%	33%	17%	0%	2.4	10.8	0.6	7.9
12 cm	0%	0%	11%	78%	11%	0%	2.8	12.9	0.4	8.7
'Ambient' 9 cm	0%	33%	27%	27%	7%	6%	2.4	8.1	1.5	5.2
10.5 cm	6%	17%	43%	11%	6%	17%	2.5	7.1	1.6	5.7
12 cm	0%	28%	28%	22%	11%	11%	2.5	8.9	0.6	6.1
'High' 9 cm	11%	11%	6%	22%	44%	6%	2.5	10.1	0.6	2.8
10.5 cm	11%	6%	22%	44%	11%	6%	2.3	9.4	0.9	4.2
12 cm	11%	6%	22%	55%	0%	6%	2.2	9.4	0.2	3.1
Not Sprayed										
'Low' 9 cm	0%	6%	33%	44%	17%	0%	2.8	9.2	1.7	6.1
10.5 cm	0%	6%	33%	50%	11%	0%	2.5	9.9	1.4	6.8
12 cm	0%	0%	38%	50%	6%	6%	2.6	10.2	0.4	8.2
'Ambient' 9 cm	6%	0%	33%	22%	39%	0%	2.8	8.8	0.7	4.9
10.5 cm	6%	5%	50%	28%	5%	6%	2.5	7.7	1.6	5.6
12 cm	0%	28%	33%	33%	6%	0%	2.7	9.7	1.1	5.2
'High' 9 cm	11%	0%	28%	33%	17%	11%	2.4	9.3	0.6	4.8
10.5 cm	11%	11%	17%	50%	11%	0%	2.6	9.9	0.7	5.7
12 cm	0%	11%	22%	39%	16%	6%	2.4	10.3	0.5	5.4

Vigour score: See Plate 1, page 35

Root score: 0 = no roots visible through base of pot
3 = many roots emerging through base of pot
See plate 2, page 35

APPENDIX II

Table 8: *Hebe* 'Autumn Glory': summary of downy mildew infection, recorded 18 April 1995

Humidity regime and plant centres		% dead plants	% plants with downy mildew score (4 = most severe) 0	1	2	3	4
Sprayed 'Low'	9 cm	0%	6%	39%	33%	17%	5%
	10.5 cm	0%	6%	50%	11%	11%	22%
	12 cm	11%	0%	39%	22%	11%	17%
'Ambient'	9 cm	6%	0%	6%	11%	27%	50%
	10.5 cm	0%	0%	22%	22%	22%	34%
	12 cm	0%	6%	11%	44%	17%	22%
'High'	9 cm	0%	0%	0%	12%	44%	44%
	10.5 cm	0%	0%	6%	16%	56%	22%
	12 cm	0%	0%	0%	44%	12%	44%
Not Sprayed 'Low'	9 cm	0%	11%	22%	33%	28%	6%
	10.5 cm	0%	22%	50%	17%	0%	11%
	12 cm	0%	16%	39%	28%	6%	11%
'Ambient'	9 cm	6%	0%	6%	6%	22%	60%
	10.5 cm	0%	0%	22%	22%	17%	39%
	12 cm	0%	0%	6%	17%	33%	44%
'High'	9 cm	0%	0%	0%	0%	33%	67%
	10.5 cm	0%	0%	0%	5%	28%	67%
	12 cm	6%	0%	0%	17%	33%	44%

Downy mildew score
0 = no infection
1 = 1 or 2 shoots infected
2 = 2-4 shoots infected
3 = all but 1 or 2 shoots infected
4 = more or less all shoots infected

APPENDIX II

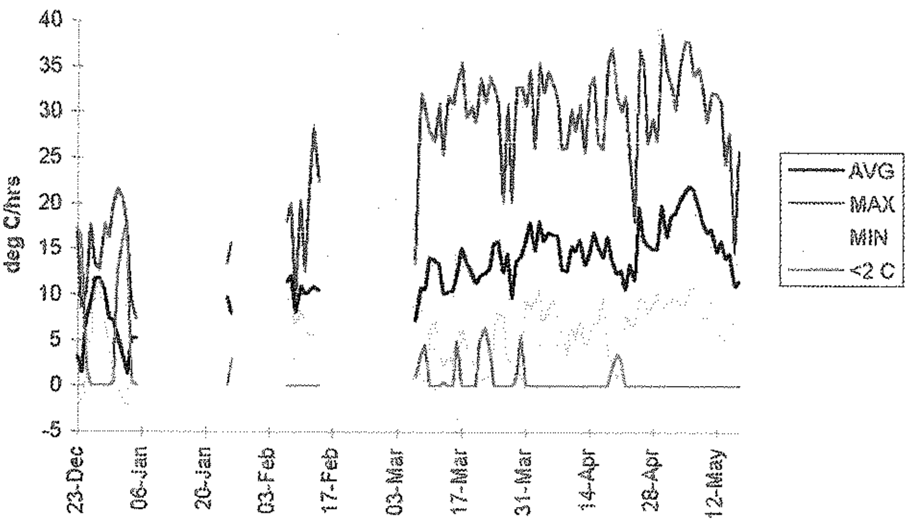
Table 9: *Hebe* 'Autumn Glory': summary of growth scores, recorded 1 July 1995

Humidity regime and plant centres		% plants with vigour score 1	2	3	4	5	6	% dead plants
Sprayed 'Low'	9 cm	11%	6%	33%	33%	11%	6%	0%
	10.5 cm	6%	6%	38%	28%	11%	11%	0%
	12 cm	5%	17%	22%	11%	17%	11%	17%
'Ambient'	9 cm	6%	16%	44%	17%	11%	0%	6%
	10.5 cm	6%	28%	33%	22%	11%	0%	6%
	12 cm	0%	28%	33%	22%	6%	0%	11%
'High'	9 cm	11%	22%	17%	11%	6%	0%	0%
	10.5 cm	17%	28%	33%	0%	5%	0%	17%
	12 cm	6%	22%	22%	33%	11%	0%	6%
Not Sprayed 'Low'	9 cm	0%	17%	28%	11%	22%	22%	0%
	10.5 cm	0%	28%	22%	22%	17%	11%	0%
	12 cm	6%	33%	6%	6%	27%	16%	6%
'Ambient'	9 cm	22%	28%	16%	6%	6%	0%	22%
	10.5 cm	6%	38%	28%	6%	11%	0%	11%
	12 cm	22%	39%	22%	6%	0%	0%	11%
'High'	9 cm	22%	39%	6%	6%	0%	0%	27%
	10.5 cm	22%	39%	17%	5%	0%	0%	17%
	12 cm	11%	56%	22%	0%	0%	0%	11%

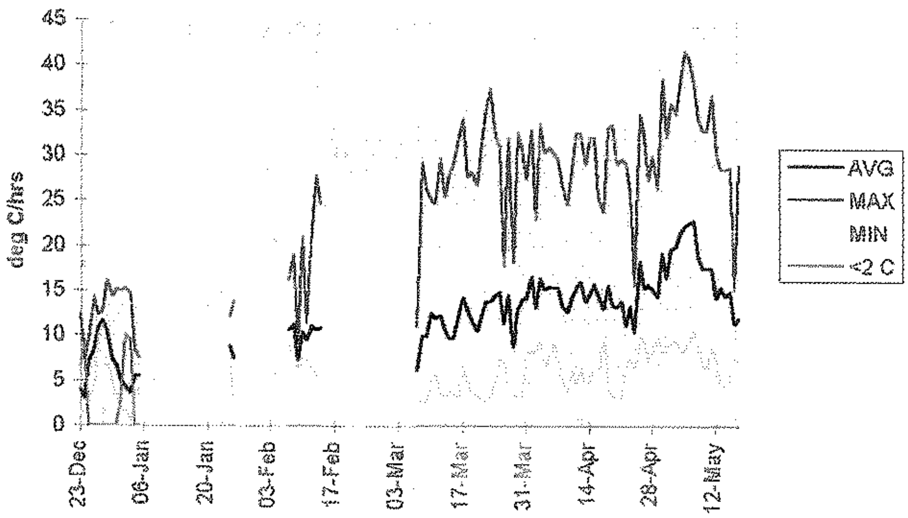
1 = least vigorous
6 = most vigorous

APPENDIX III

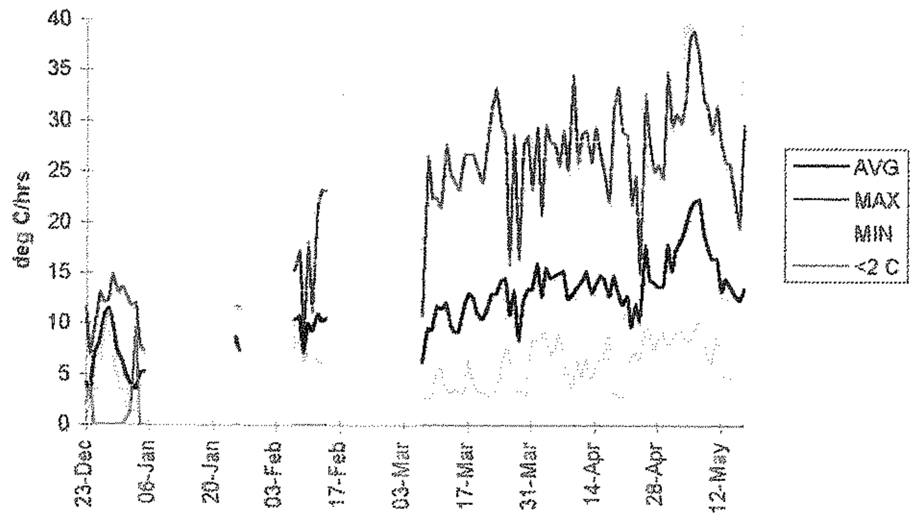
Summary of temperature (°C) for trial tunnels



'Low' humidity tunnel



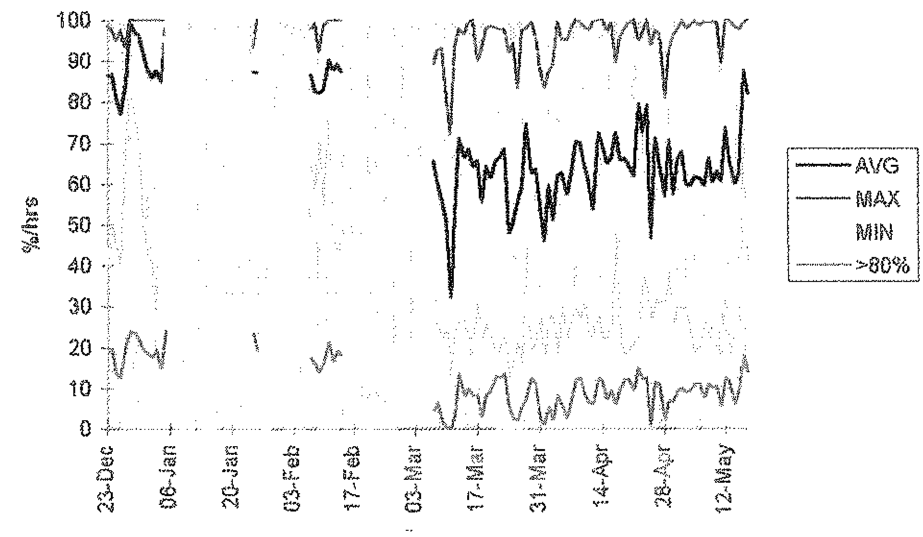
'Ambient' humidity tunnel



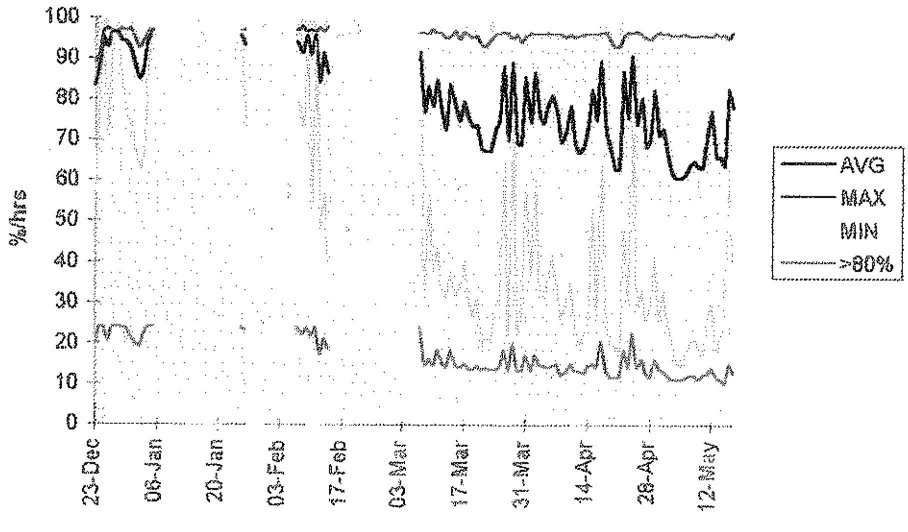
'High' humidity tunnel

APPENDIX III

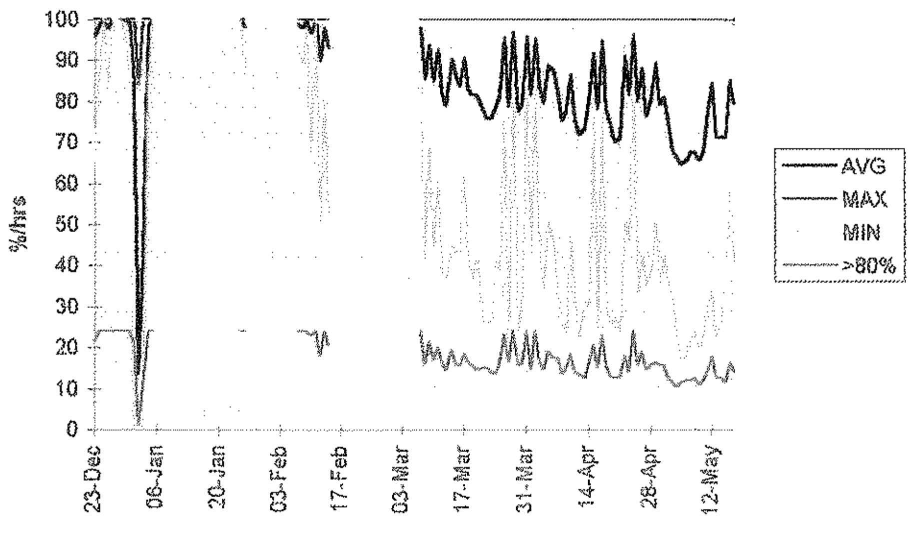
Summary of % RH for trial tunnels



'Low' humidity tunnel



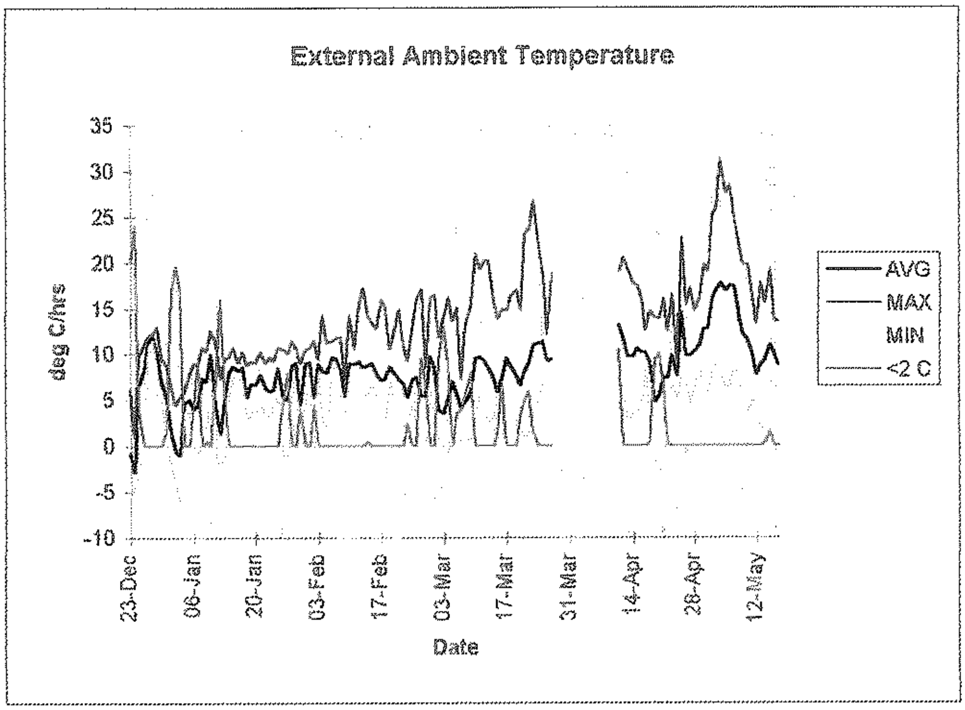
'Ambient' humidity tunnel

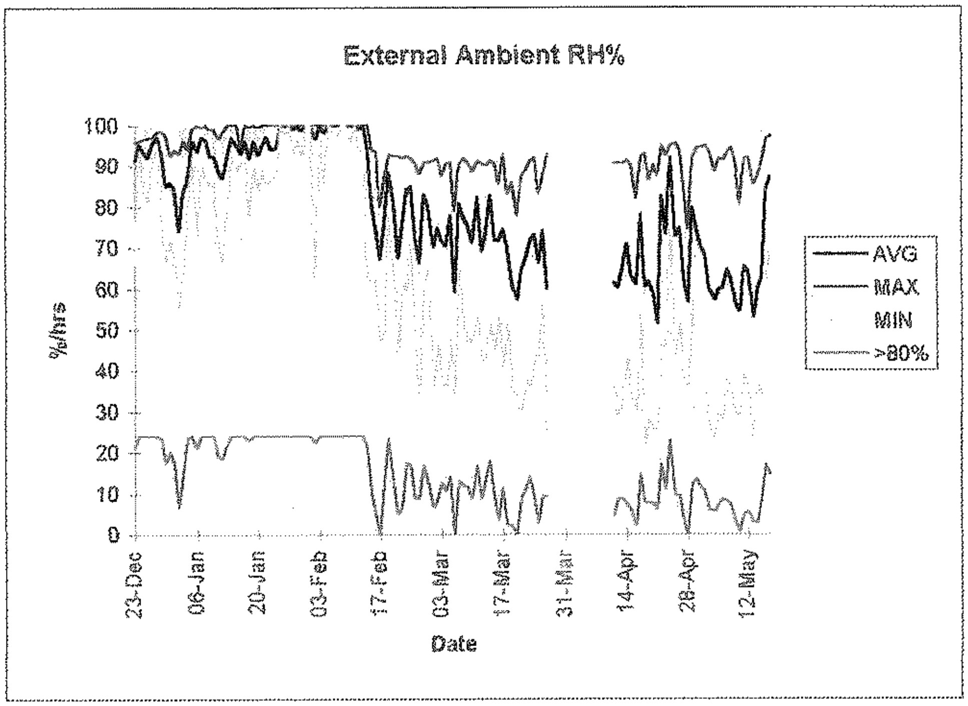


'High' humidity tunnel

APPENDIX III

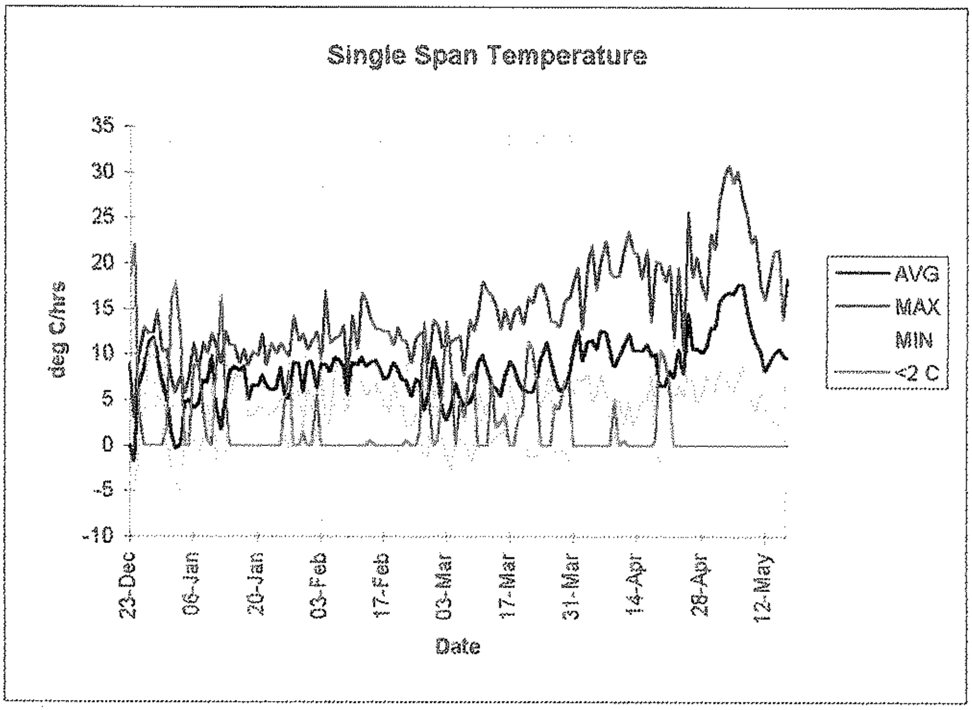
External ambient temperature (°C) and RH (%) late Dec 1994 - mid May 1995

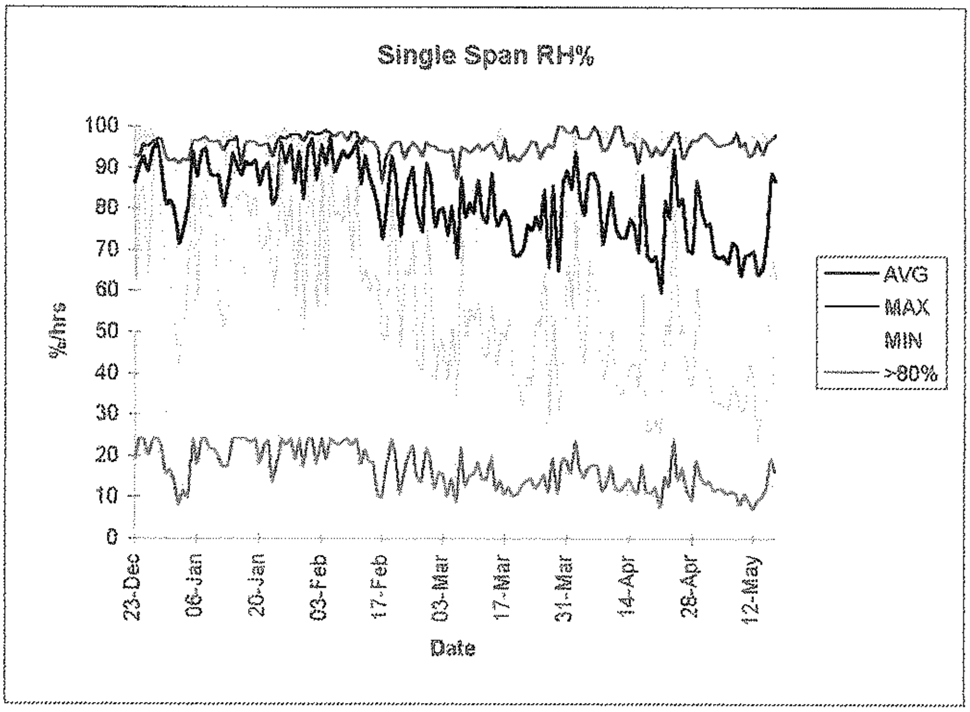




APPENDIX III

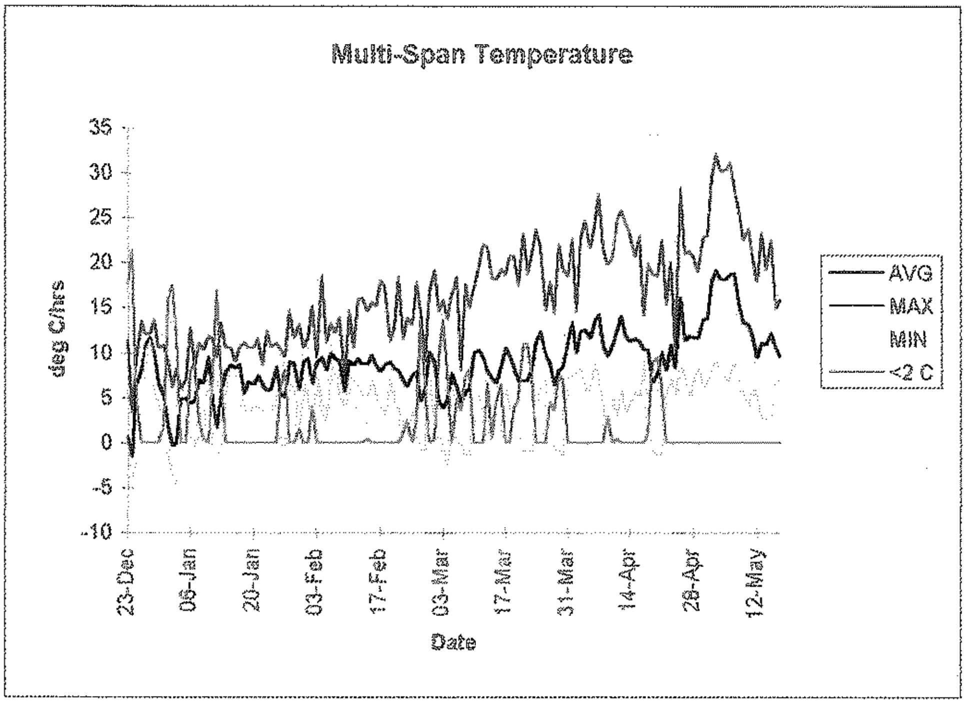
Temperature (°C) and RH (%) recorded in single span polythene tunnel (5.5m wide, 19.7m long, 2.8m high) with a netting skirt to a height of 1m.

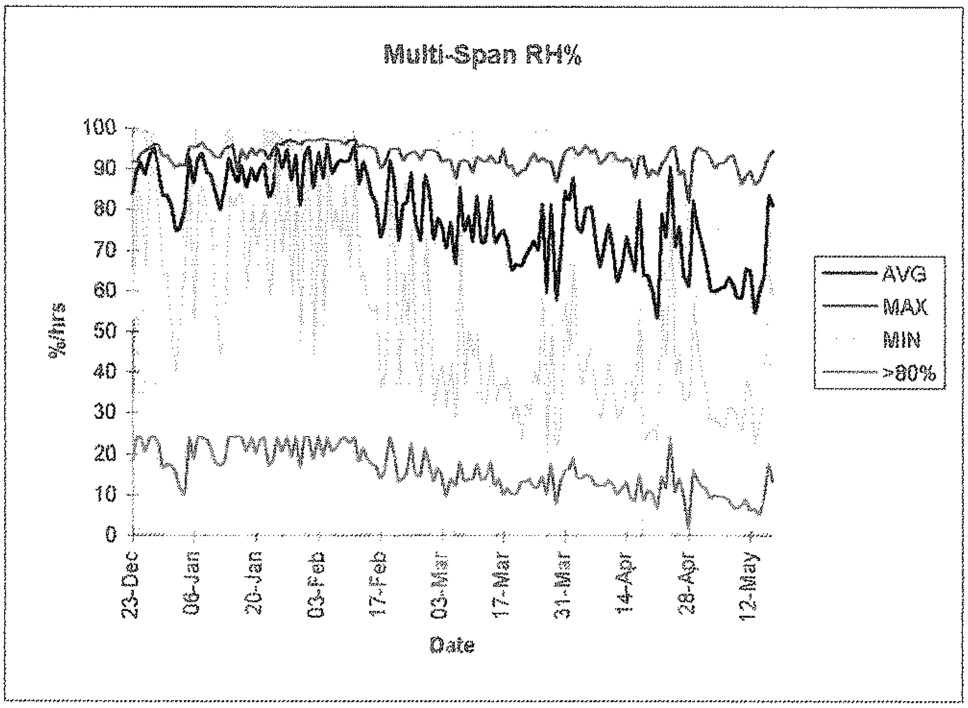




APPENDIX III

Temperature (°C) and RH (%) recorded in a triple span tunnel (19.3m wide, 14.0m long, 3.8m high) with side ventilation.





APPENDIX IV

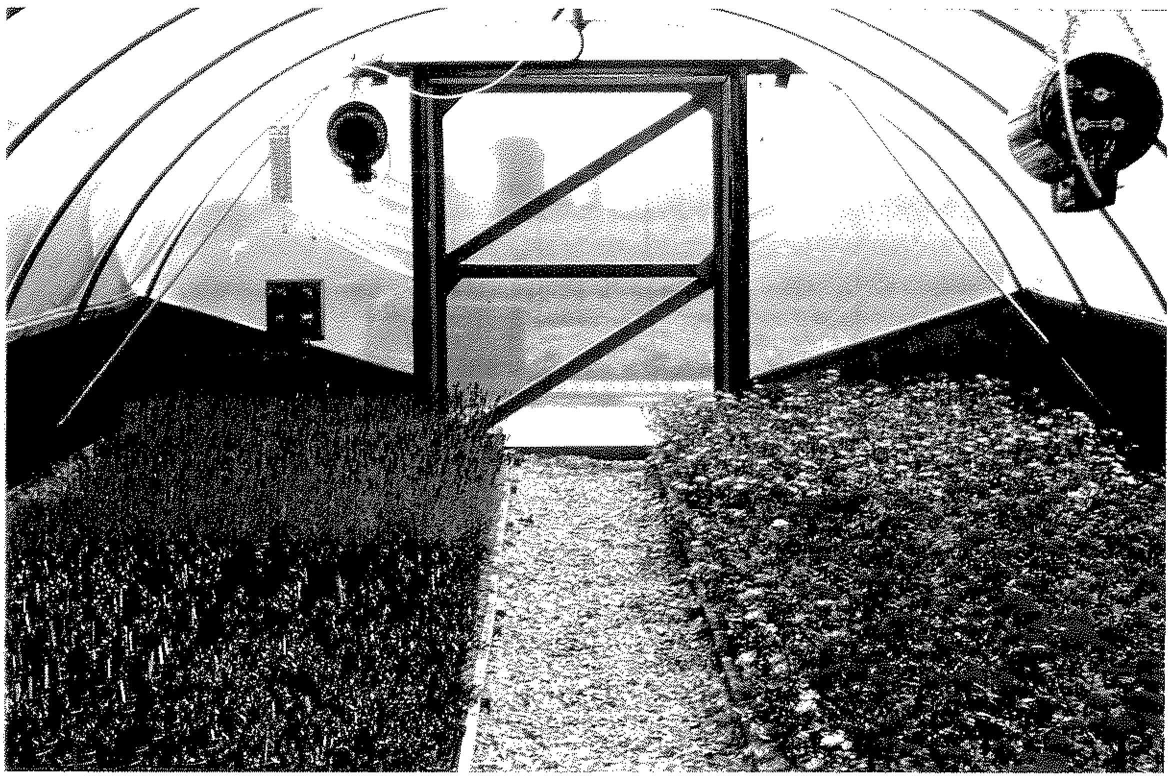
Plate 1: Vigour categories for *Lavandula angustifolia* 'Hidcote' used at final assessment with '5' on left and '1' on right

Plate 2: 'Rooting through' categories for *Lavandula angustifolia* 'Hidcote' used at final assessment with '3' on left and '1' on right

APPENDIX IV

Plate 3: Vigour categories for *Hebe* 'Autumn Glory' used at final assessment with '6' on left and '1' on right

Plate 4: General view of 'high' humidity tunnel prior to final assessments



APPENDIX V

Contract between HRI (hereinafter called the "Contractor") and the Horticultural Development Council (hereinafter called the "Council") for a research/development project.

1. TITLE OF PROJECT

Contract No: HNS 49b
Contract Date: 18.05.95

INFLUENCE OF ENVIRONMENTAL FACTORS AND CROP MANAGEMENT ON THE INCIDENCE OF DISEASE ON LINERS OF OVERWINTERED HARDY NURSERY STOCK SPECIES

2. BACKGROUND AND COMMERCIAL OBJECTIVE

Young liners of many hardy nursery species are grown 'cold' in polythene tunnels overwinter, with only sufficient heat to provide protection from frosts. High relative humidity levels (RH) frequently prevail, especially early in the mornings when dew point can be reached. Ventilation is often poor, with a resulting lack of air movement. Such environmental conditions favour the development of *Botrytis* and downy mildews (*Peronospora* spp), and plant losses can be high on susceptible species during this overwintering period.

With increasing pressure to reduce the use of pesticides, coupled with the diminishing number of chemicals available and the ever present risk of pathogen resistance, the manipulation of environmental conditions may offer an alternative method for controlling, or at least reducing, the incidence and/or spread of such pathogens.

Such an approach was demonstrated in the programme of work carried out under HNS 49a in 1993/94 (this work was jointly funded by Electricity Association Technology Ltd). Incidence of disease, and plant quality *per se*, was monitored in three different relative humidity regimes (low, ambient, high), on four test species, including *Hebe* and Rose. By late spring the infection by downy mildew on both of these species was high enough to render the majority of plants in the 'high' humidity regime unsaleable, even where a spray programme had been applied. In contrast, plants grown in a 'low' humidity regime carried less disease, particularly on the seephose irrigated sandbed.

Aspects of husbandry, for example, plant spacing, may also affect the incidence/spread of disease, due to a change in the microclimate around individual plants. This has been highlighted in work carried out by Dr Tim O'Neill on container-grown roses out of doors (Project HNS53), where the incidence and severity of downy mildew (*Peronospora sparsa*) was reduced as spacing increased.

The three small, single span polythene tunnels used for last year's dehumidification project are available for this work. These tunnels are ideal for achieving a range of RHs for experimental work, but are not typical of those used by the industry. It is likely that the RH's in larger (particularly taller) tunnels will be very different to those recorded in the small trial tunnels, depending on both length/height and number of spans. Therefore information is needed on RH levels in a range of tunnel sizes, to assess the risks of disease incidence/spread, and to determine the economic feasibility of dehumidification in these larger structures.

The work proposed for this year would comprise two components:-

Firstly, trial work carried out in the three small experimental tunnels, investigating the effect of three different RH regimes and 3 plant spacings on the incidence of disease, and on plant quality of four test subjects.

Secondly, monitoring of RH in a range of tunnel sizes at HRI Efford and possibly elsewhere.

3. POTENTIAL FINANCIAL BENEFIT TO THE INDUSTRY

Top quality, disease free plugs/liners are essential for the production of quality containerised nursery stock. For certain key species, for example *Hebe* and pot grown roses, the incidence of diseases such as downy mildew over the winter/early spring period necessitates the application of a rigorous spray programme. This is costly, both in terms of chemicals and labour. If environmental conditions and aspects of crop management could be modified, simply and cheaply, to reduce disease pressure, then considerable savings are potentially possible.

4. SCIENTIFIC/TECHNICAL ASPECTS OF THE WORK

To investigate the effect of relative humidity regime and plant population/spacing on the incidence of downy mildew/*Botrytis* on *Hebe* and Rose and *Phomopsis* on Lavender on plants grown under protection over the winter period. To monitor the relative humidities in polythene tunnels of different sizes.

5. CLOSELY RELATED WORK COMPLETED OR IN PROGRESS

Work in HNS49 last year highlighted the influence of relative humidity on the incidence of downy mildew on roses and *Hebe*.

Fungicide programmes for the control of downy mildew on *Hebe* have been investigated in HNS21.

Similarly, the chemical control of downy mildew on roses has been investigated in HNS 24 & 53.

6. DESCRIPTION OF THE WORK

1. Trial work at HRI Efford

The 3 small polythene tunnels used for last year's work will be utilised, and will be unheated, except for the provision of frost protection.

Proposed treatments

Target relative humidity

a) 'low' RH (dehumidification to reduce RH to below 80%)
b) 'ambient' RH
c) 'high' RH (enhanced with fog to maintain >95% RH)

Plant spacing

a) plant centres at 9 cm (i.e. pot thick)
b) plant centres at 10.5 cm (i.e. 1.5 cm between pots)
c) plant centres at 12 cm (i.e. 3 cm between pots)

(All plants to be potted into 9 cm round pots)

Chemical control of disease

a) disease control sprays to be applied as required for each species
b) no disease control sprays to be applied

Species

Main trial: *Hebe* 'Autumn Glory'
Lavandula angustifolia 'Hidcote'
Rose 'Scarlet Pimpernel' (miniature)
Rose 'Magic Carousel' (miniature)

Observation: Modular trays of: *Hebe* 'Great Orme'
Hebe x franciscana 'Blue Gem'
Hebe x franciscana 'Variegata'
Hebe 'Gloriosa'
Heathers (esp. *Erica*)

Growing system

Sandbed with seephose irrigation

Experimental layout

Six replicates of each spacing per species in each humidity regime, half to be sprayed for disease control as required. The humidity regimes are not replicated.

Assessments

a) crop diary
b) records of air temperature and RH in each of the 3 tunnels, throughout the trial period using a Delta T logger
c) photographic records of growth/disease incidence as appropriate
d) records of disease incidence at the end of the trial (interim records will be made if required)
e) records of plant quality and growth at the end of the trial

2. Additional RH monitoring

Several different sized polythene tunnels representative of those used in the industry will be identified, and the RH measured over time using data logging equipment. *E.A. Technology Ltd will supply this equipment and the manpower for 'down loading' data.*

Advice will be sought from Bernard Bailey at Silsoe regarding the siting of probes for RH measurement etc.

7. COMMENCEMENT DATE, DURATION AND REPORTING

Start date: 01.12.94, duration 10 months

The experimental work will be completed by June 1995 and the final report will be produced by the end of September 1995.

8. STAFF RESPONSABILITIES

Lyn Andrews, in liaison with Margaret Scott and with advice on pathology aspects from Dr Tim Pettitt.

9. LOCATION

HRI Efford

10. COSTS

HDC
E.A. Technology (Payment in kind see below)
Total Cost

The "in kind" costs incurred by E.A. Technology Ltd comprise:

i) the provision of RH monitoring equipment (and manpower to service this equipment);

ii) the selection and supply of the dehumidification unit for the trial at HRI Efford, and

iii) assistance with interpretation of technical data and assessment of economic feasibility of dehumidification.

TERMS AND CONDITIONS

The Council's standard terms and conditions of contract shall apply.

Signed for the Contractor(s)	Signature..
	Position......C & M Manager H&L......
	Date.........4/1/96.........
Signed for the Contractor(s)	Signature..
	Position..
	Date..
Signed for the Council	Signature..
	Position.....CHIEF EXECUTIVE.....
	Date.........24.5.94.........