Grower Summary

HNS 182

Developing optimum irrigation guidelines for reduced peat, peat-free and industry standard substrates

Annual 2011

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Project Number:	HNS 182
Project Title:	Developing optimum irrigation guidelines for reduced peat, peat-free and industry standard substrates
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Contractor:	East Malling Research
Industry Representative:	John Adlam, Dove Associates Malcolm Dick, John Richards Nurseries Bill Godfrey, W. Godfrey & Sons Alastair Hazell, Darby Nursery Stock Ltd Susie Holmes, Consultant
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Headline

- The optimum range of substrate water contents for reduced peat, peat-free and industry standard media have been identified
- Irrigation set points for the three substrates that optimise plant quality but minimise losses of water and fertiliser were determined

Background and expected deliverables

The HNS sector is the largest user of peat in the UK horticultural industry. Around 450,000 m^3 of growing medium, of which about 80% is peat, is used annually for hardy nursery stock production in the UK. Although some customers request peat-free production (*e.g*. The National Trust), the majority do not and so at the moment, there is little commercial pressure to reduce peat use. However, following the publication of Defra's consultation document in December 2010 ('Consultation on reducing the horticultural use of peat in England 2010'), many growers are becoming increasingly concerned about the proposed phasing out of peat in the horticultural industry. For the Government and the public sector, the target is to be peat free by 2015; and for the professional horticulture and landscaping sectors to be peat free by 2030 at the latest.

Most growers acknowledge that irrigation and nutrient regimes will need to be modified when using reduced peat and peat-free substrates. The relatively poor water-holding capacity of most peat-free alternatives will necessitate more frequent irrigation events but over-watering must be avoided to minimise run-through of water and dissolved fertilisers and limit environmental pollution. To help facilitate the development of 'best' or 'better' irrigation practice during the proposed transition to peat-free production, new scientifically-derived irrigation set points are needed that optimise substrate moisture content for the reduced peat and peat-free media likely to be used by HNS growers in the future.

In this project, the 'optimum' substrate moisture content is defined as one that supports good, healthy plant growth while avoiding over-wet conditions so that leaching of irrigation water and fertilisers is minimised or eliminated. Irrigation set points will be identified for each substrate and used to develop new guidelines to help growers overcome problems associated with over-watering reduced peat and peat-free alternatives.

The overall aim of the project is to develop and implement improved irrigation scheduling guidelines for reduced peat, peat-free and industry standard media that help growers comply

with legislation, optimise plant quality, reduce costs and gain confidence in growing HNS in peat alternatives.

Summary of the project and main conclusions

Experimental plant species and commercially available reduced peat, peat-free and industry standard substrates were selected after consultation with members of the project steering group. The following widely-produced crops were chosen as they are moderately resilient to substrate drying and so were considered a good choice of 'indicator' species:

- *Sidalcea oregana* 'Party Girl'
- *Ribes sanguineum* 'Koja'
- *Escallonia rubra* 'Crimson Spire'

The following substrates were chosen (for use in years 1 and 2) since they are considered to be good quality brands that are (or are becoming) widely used by UK growers:

- **Industry standard:** substrate based on 25% bark, 75% peat supplied by Sinclair
- **Reduced peat:** substrate based on 25% wood fibre, 25% bark, 50% peat supplied by Bulrush
- **Peat free:** substrate based on peat-free materials (composted green waste and bark) supplied by Vital Earth

Specification details were obtained for each substrate; additionally each was analysed for air filled porosity, particle size distribution, pH, density, dry matter, dry density, Ca, Cl, Mg, P, K, Na, N, EC and trace elements. The results of these analyses are given in Appendix I (Tables A1, A2).

Bare-rooted *Sidalcea* and 9 cm liners of *Ribes* and *Escallonia* were potted in to 2 L pots containing one of the three substrates. Controlled release fertiliser (Osmocote Pro 12-14 month, 18+9+10 +2 MgO + trace elements) was incorporated at 3 kg per 1000 L for *Sidalcea* and 5 kg per 1000 L for *Ribes* and *Escallonia*. All plants were grown on in a glasshouse maintained at 15 / 10 ºC (day / night) with supplementary lighting supplied from sodium lamps during a 12 h photoperiod. Plants were hand-watered during establishment. The frequency and duration of irrigation events required to replace water lost by transpiration was then calculated daily. Irrigation was supplied to each pot *via* a dripper stake and bootlace connected to a pressure compensated 2 L h^{-1} emitter (Figure GS1).

Figure GS1. Irrigation was scheduled to *Sidalccea* to match demand with supply. Photo taken on 23 March 2011

To establish irrigation set points a controlled environment is required, therefore the plants were maintained under glass for the duration of the experiment.

To identify the optimum range of substrate moisture contents, the approach adopted was to first determine volumetric substrate moisture content (VSMC) at 'pot capacity' then impose gradual substrate drying on half of the plants and monitor physiological responses such as stomatal conductance, transpiration rate and leaf extension growth (Figure GS2). *Sidalcea* were used for the first experiment once the root system was fully developed and plants were transpiring freely.

The VSMC at which statistically significant differences in physiological responses between the well-watered (WW) and water-limited (WL) treatments were first detected were identified. The VSMC at which wilting was first observed and at which permanent wilting occurred were also determined for each substrate.

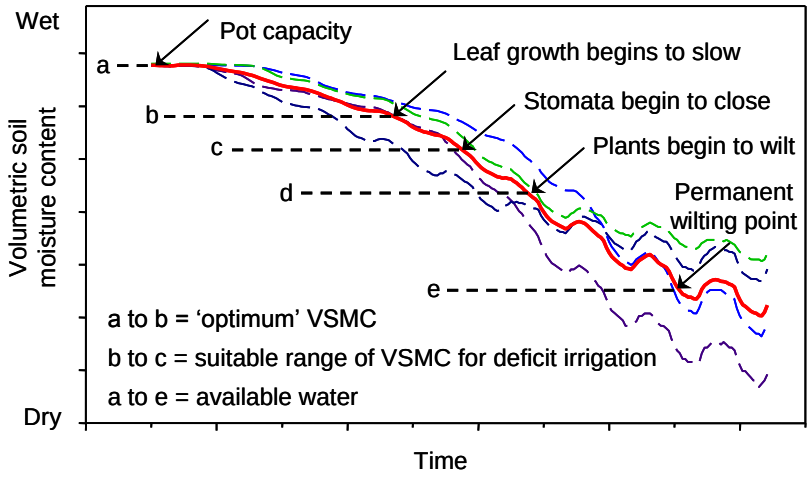

Figure GS2. Theoretical framework used to identify optimum substrate moisture contents of the different substrates. The solid line represents mean VSMC. Plant physiological responses to drying soil do not always occur in this order

Sidalcea

Physiological responses to substrate drying were first detected in *Sidalcea* plants growing in the peat-free and 50% peat mixes (Figure GS3). Although leaf extension rate is the first detectable response to substrate drying in many plant species, in *Sidalcea* trans-pirational water loss and stomatal conductance were the most sensitive and reliable indicators of drying substrate (Figure GS3).

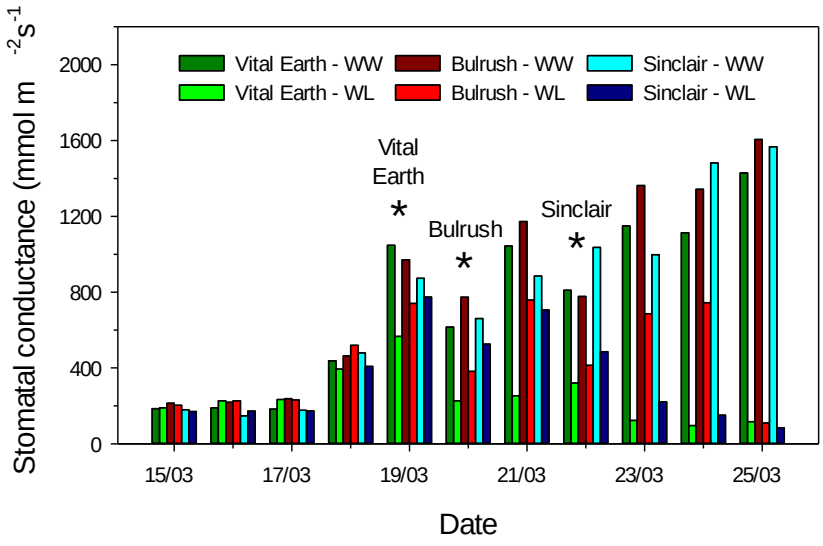

Figure GS3. Statistically significant differences in stomatal conductances between well-watered (WW) and water-limited (WL) treatments were first detected on March 19, 20 and 22 for *Sidalcea* plants grown in Vital Earth, Bulrush and Sinclair substrates, respectively

The onset of wilting was delayed by one day in plants grown in the industry-standard substrate; first signs of wilting were noted on some plants in the reduced-peat and peat-free substrates on 19 March 2011. By 21 March 2011, the extent of wilting was similar in all water-limited treatments and the degree of wilting continued to develop at similar rates thereafter (Figure GS4). Average plant heights on 29 March 2011 were 29, 30 and 27 cm in well-watered Vital Earth, Bulrush and Sinclair substrates, respectively. Average heights were reduced by 38, 40 and 4% in water-limited Vital Earth, Bulrush and Sinclair substrates, compared to well-watered values. No differences in overall plant quality were noted and all well-watered plants were classed as 'marketable' by the project steering group.

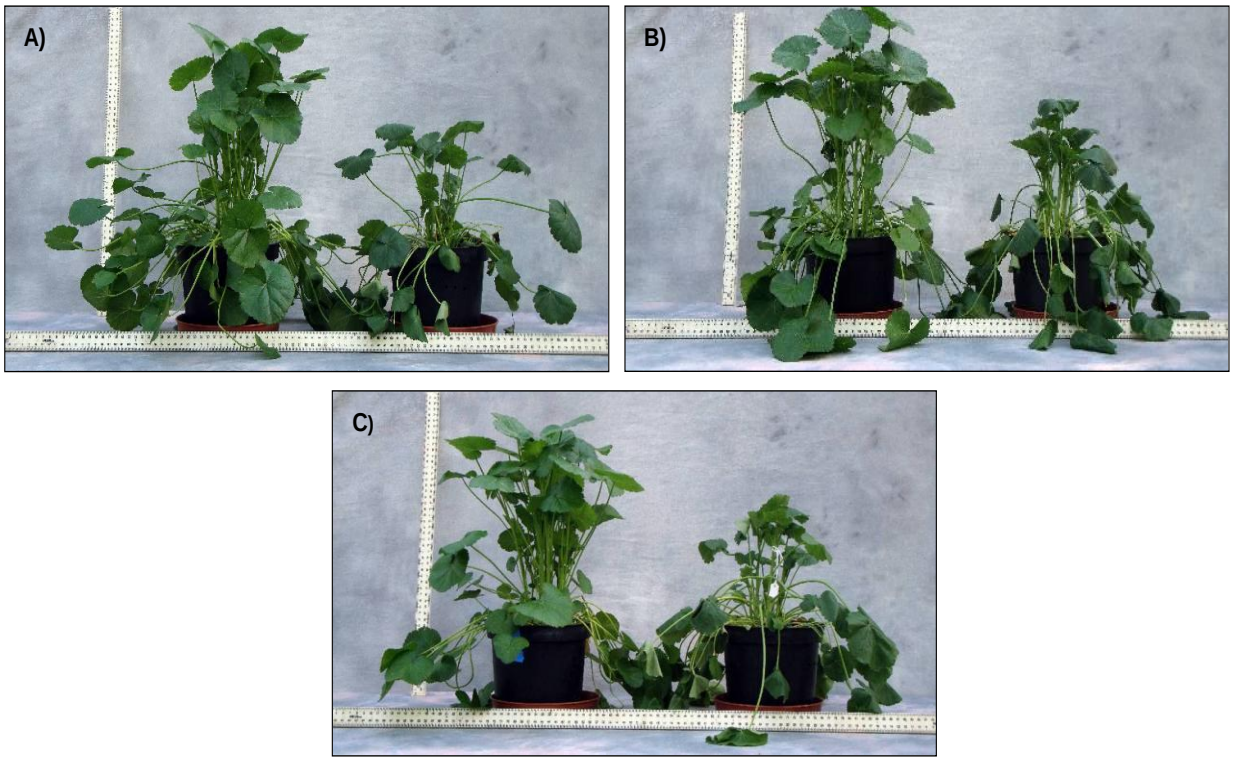

Figure GS4. Well-watered and water limited *Sidalcea* grown in A) Vital Earth, B) Bulrush and C) Sinclair substrates. Photos were taken on 25 March 2011

Table GS1. *Sidalcea* plant-and-pot weights and VSMC for each of the three substrates when significant differences in physiological responses were first detected in water-limited plants compared to well-watered plants. Results are means of seven replicate plants with associated standard errors of the mean values

Physiological parameter	Pot weights and VSMC when physiological response first detected					
	Vital Earth		Bulrush		Sinclair	
	Weight (g)	VSMC (m^3 m^{-3})	Weight (g)	VSMC (m^3 m^{-3})	Weight (g)	VSMC (m^3 m^{-3})
Stomatal conductance	1079 ± 54	0.251 ± 0.03	986 ± 72	0.247 ± 0.03	920 ± 26	0.187 ± 0.01
Whole-plant transpiration	1079 ± 54	0.251 ± 0.03	1092 ± 65	0.247 ± 0.03	987 ± 40	0.217 ± 0.01
Evapotranspiration per degree hour	1079 ± 54	0.251 ± 0.03	1092 ± 65	0.247 ± 0.03	987 ± 40	0.217 ± 0.01
Petiole extension	992 ± 51	0.214 ± 0.03	702 ± 23	0.155 ± 0.02	1036 ± 41	0.231 ± 0.02

The optimum range of substrate moisture content lies between the VSMCs at the point when physiological responses are triggered (Table GS1) and pot capacity. However, a ‘’low risk’ strategy was developed to accommodate the inevitable logistical constraints to irrigation scheduling that occur during commercial production. Thus, the VSMC recorded 24 h before the initiation of the most sensitive response was used as the lower irrigation set point (Table GS2). Corresponding plant-and-pot weights are also presented.

Table GS2. The range of optimum values for plant-and-pot weights and VSMCs for *Sidalcea* grown in each of the three substrates. Results are means of seven replicate plants growing in 2 L pots

Substrate	Optimum plant-and-pot weights and VSMCs for each substrate			
	Pot weight (g)		VSMC (m^3 m^{-3})	
	Pot capacity	Lower	Pot capacity	Lower
Sinclair	1470	1036	0.55	0.23
Bulrush	1310	1130	0.46	0.34
Vital Earth	1370	1130	0.46	0.29

Ribes

Physiological responses to substrate drying were first detected in *Ribes* plants growing in the peat-free mix, indicated by a significant decrease in transpirational water loss four days after withholding water (Figure GS5).

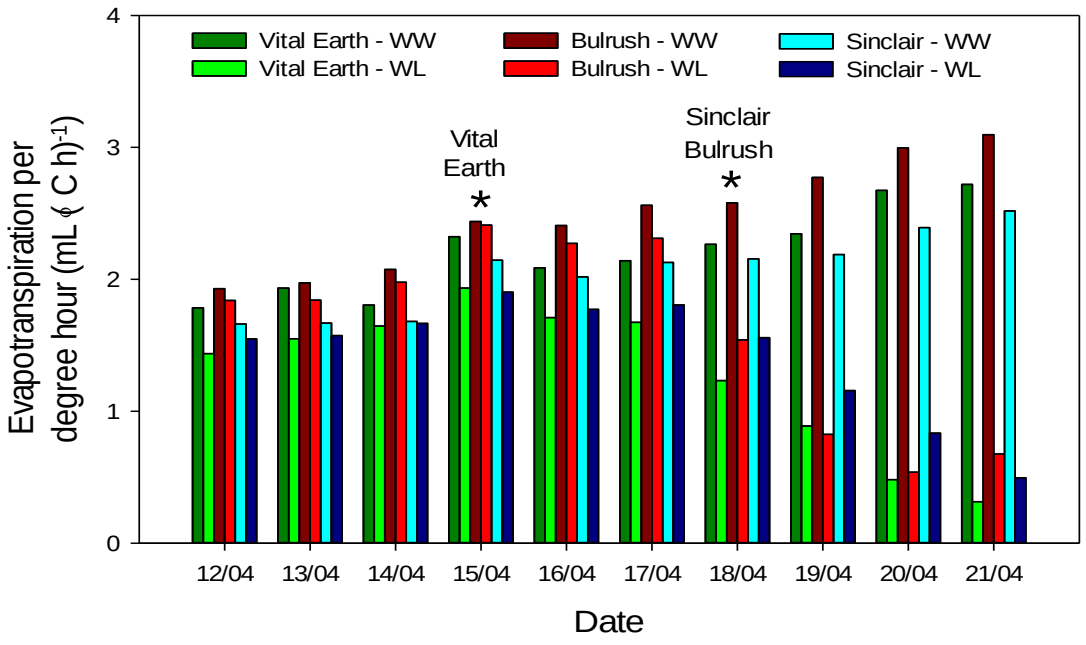

Figure GS5. Statistically significant differences in evapotranspiration between well-watered (WW) and water-limited (WL) treatments were first detected on April 15 for plants grown in Vital Earth substrate and April 18 for *Ribes* plants grown in Bulrush and Sinclair substrates

The first signs of wilting were noticed on one or two plants in all substrates on 19 April 2011, and by 25 April 2011, all of the plants growing in Bulrush substrate, and 4 of the plants growing in each of the Vital Earth and Sinclair substrates had wilted (Figure GS6). Average plant heights on 27 April 2011 were 39, 38 and 39 cm in well-watered Vital Earth, Bulrush and Sinclair substrates, respectively. Average heights were reduced by 9, 23 and 2% in water-limited Vital Earth, Bulrush and Sinclair substrates, compared to well-watered values. No differences in overall plant quality were noted.

Figure GS6 Well-watered and water limited *Ribes* grown in A) Vital Earth, B) Bulrush and C) Sinclair substrates. Photos were taken on 27 April 2011

The optimum range of substrate moisture content lies between the VSMCs at the point when physiological responses are triggered (Table GS3) and pot capacity.

Table GS3. *Ribes* plant-and-pot weights and VSMC for each of the three substrates when significant differences in physiological responses were first detected in water-limited plants compared to well-watered plants. Results are means of six replicate plants with associated standard errors of the mean values

Physiological parameter	Pot weights and VSMC when physiological response first detected					
	Vital Earth		Bulrush		Sinclair	
	Weight (g)	VSMC (m^3 m^{-3})	Weight (g)	VSMC (m^3 m^{-3})	Weight (g)	VSMC (m^3 m^{-3})
Stomatal conductance	1010 ± 40	0.198 ± 0.01	718 ± 24	0.136 ± 0.01	813 ± 43	0.146 ± 0.01
Whole-plant transpiration	1153 ± 30	0.260 ± 0.02	718 ± 24	0.136 ± 0.01	921 ± 55	0.192 ± 0.03
Evapotranspiration per degree hour	1153 ± 30	0.260 ± 0.02	718 ± 24	0.136 ± 0.01	921 ± 55	0.192 ± 0.03
Leaf extension	718 ± 14	0.112 ± 0.01	594 ± 12	0.110 ± 0.004	643 ± 12	0.106 ± 0.003

As for *Sidalcea*, in order to accommodate the logistical constraints to irrigation scheduling that occur during commercial production the VSMC recorded 24 h before the initiation of the most sensitive response was used as the lower irrigation set point (Table GS4). Corresponding plant-and-pot weights are also presented.

Table GS4. The range of optimum values for plant-and-pot weights and VSMCs for *Ribes* grown in each of the three substrates in 2 L pots. Results are means of seven replicate plants (pot capacity) and six replicate plants (Lower pot weight).

Substrate	Optimum plant-and-pot weights and VSMCs for each substrate			
	Pot weight (g)		VSMC (m^3 m^{-3})	
	Pot capacity	Lower	Pot capacity	Lower
Sinclair	1405	1000	0.49	0.21
Bulrush	1335	820	0.48	0.16
Vital Earth	1380	1205	0.43	0.30

Escallonia

Physiological responses to substrate drying were detected in *Escallonia* plants growing in all substrates on the same date, indicated by a significant decrease in stomatal conduc-tance and transpirational water loss (Figure GS7).

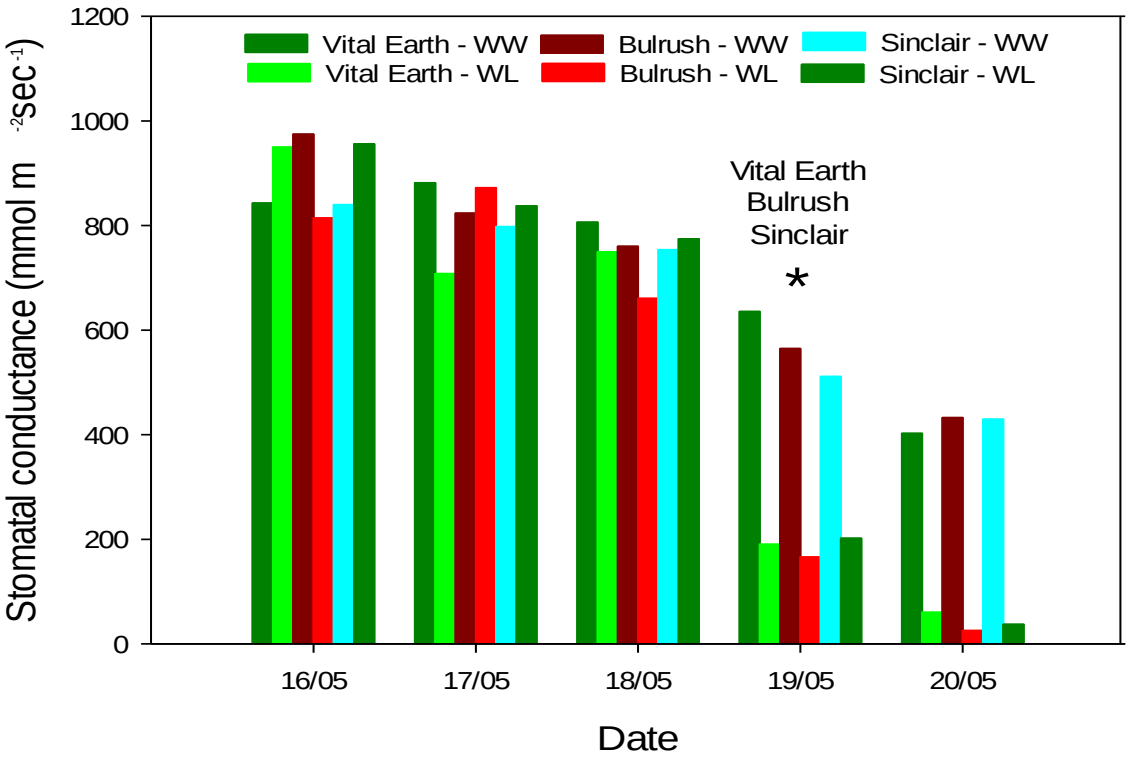

Figure GS7. Statistically significant differences in stomatal conductance between well-watered (WW) and water-limited (WL) treatments were first detected on May 19 for *Escallonia* plants grown in all substrates

The first signs of wilting were noticed in 4, 5 and 4 of the plants in Vital Earth, Bulrush and Sinclair substrates respectively on 19 May 2011, and by 25 May all of the plants in each substrate had wilted (Figure GS8).

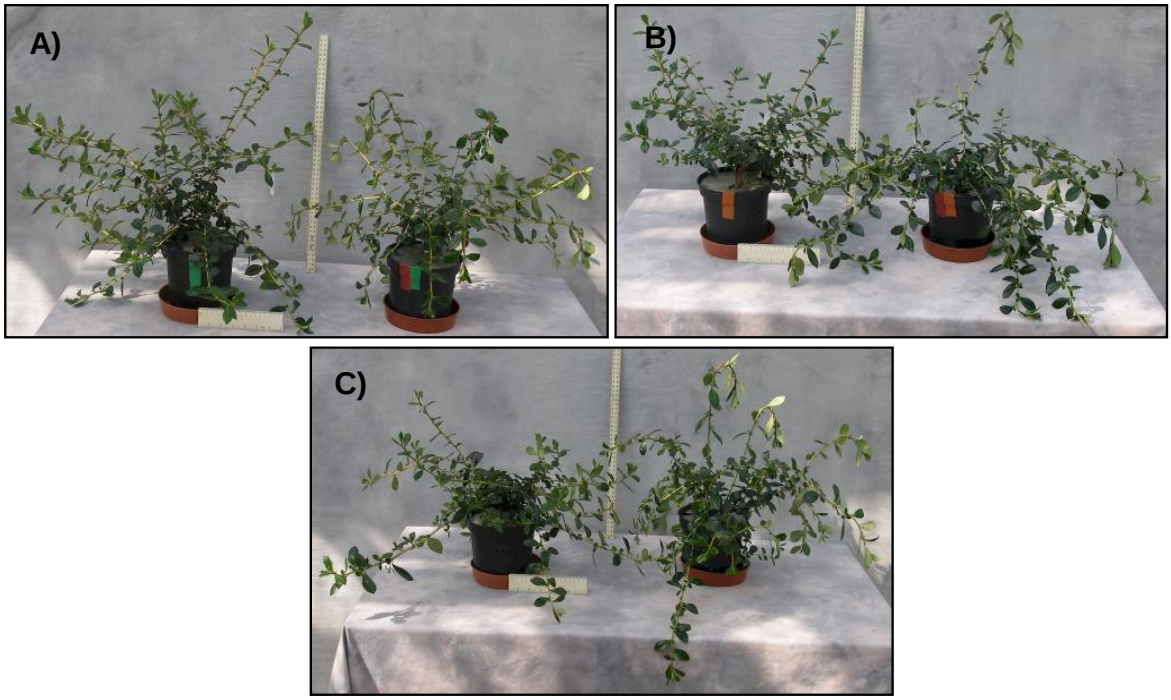

Figure GS8. Well-watered and water limited *Escallonia* grown in A) Vital Earth, B) Bulrush and C) Sinclair substrates. Photos were taken on 19 April 2011

Average plant spread on 23 May 2011 was 84, 87 and 85 cm in well-watered Vital Earth, Bulrush and Sinclair substrates, respectively. Average spreads were reduced by 11, 0 and 6% in water-limited Vital Earth, Bulrush and Sinclair substrates, compared to well-watered values. No differences in overall plant quality were noted.

The optimum range of substrate moisture content lies between the VSMCs at the point when physiological responses are triggered (Table GS5) and pot capacity. As for *Sidalcea* and *Ribes,* the VSMC recorded 24 h before the initiation of the most sensitive response was used as the lower irrigation set point (Table GS6). Corresponding plant-and-pot weights are also presented.

Table GS5. *Escallonia* plant-and-pot weights and VSMC for each of the three substrates when significant differences in physiological responses were first detected in water-limited plants compared to well-watered plants. Results are means of seven replicate plants with associated standard errors of the mean values

Physiological parameter	Pot weights and VSMC when physiological response first detected					
	Vital Earth		Bulrush		Sinclair	
	Weight (g)	VSMC (m^3 m^{-3})	Weight (g)	VSMC (m^3 m^{-3})	Weight (g)	VSMC (m^3 m^{-3})
Stomatal conductance	903 ± 19	0.210 ± 0.01	811 ± 34	0.196 ± 0.01	856 ± 22	0.187 ± 0.01
Whole-plant transpiration	903 ± 19	0.210 ± 0.01	811 ± 34	0.196 ± 0.01	856 ± 22	0.187 ± 0.01
Evapotranspiration per degree hour	903 ± 19	0.210 ± 0.01	811 ± 34	0.196 ± 0.01	856 ± 22	0.187 ± 0.01
Leaf extension	-	-	673 ± 22	0.128 ± 0.01	689 ± 14	0.125 ± 0.005

Table GS6. The range of optimum values for plant-and-pot weights and VSMCs for *Escallonia* grown in each of the three substrates. Results are means of seven replicate plants

Substrate	Optimum plant-and-pot weights and VSMCs for each substrate			
	Pot weight (g)		VSMC (m^3 m^{-3})	
	Pot capacity	Lower	Pot capacity	Lower
Vital Earth	1335	1010	0.50	0.25
Bulrush	1320	940	0.55	0.24
Sinclair	1455	1015	0.55	0.32

For the three substrates used in this project, the set points should be appropriate for use with plants of different ages/sizes and for plants grown indoors or outdoors. Although the pot weight threshold value will depend on pot size, the VSMC values should be similar in pots of different sizes for the same growing media. However, care needs to be taken when applying

the values to different growing media as, even if the blend is similar, the physical characteristics (e.g. bulk density) could be significantly different. Practical advice for using trigger values for growing media with different physical characteristics will be developed during the project.

These values will be used in Year 2 in experiments on the East Malling Water Centre (EMWC) to optimise scheduling of irrigation (frequency and duration) to each substrate to match crop demand. The effects of the different substrates on plant quality will be determined using criteria developed by the project steering group.

Financial benefits

Full cost-benefit analyses at commercial nurseries would be required to quantify precisely the potential financial benefits arising from this project. However, significant cost savings are anticipated due to lowered production costs, more efficient use of resources and reduced plant wastage.

Figures provided by Will George (ADAS consultant), from the Horticultural Trade Association's Nursery Business Improvement Scheme (NBIS) suggest that the average value of plant waste from five nurseries during the period 2002 – 2004 was between £21,000 - £27,000 per annum or between 7 and 10% of turnover. Poor watering of peat-based growing media accounted for 3.2% of the waste, which equates with a loss of approximately £1,000 for each nursery per year. This particular project aims to minimise losses through poor watering during the transition to reduced-peat and peat-free substrates which could be much more substantial than those reported for peat-based media.

For those growers using mains water, scheduling irrigation effectively to match demand with supply to achieve modest water savings of 25% could also reduce average water bills by £1,410 per year (based on figures supplied from NBIS for 2006-2007).

Action points for growers

The emphasis in the first project year has been on developing a robust and reliable approach to determine the optimum moisture contents for the three substrates. Following trials on the EMWC in 2011, action points for growers will be included in the next annual report.