AHDB HORTICULTURE

Interim Project Report

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Project details

1.	AHDB Horticulture Project code	CP138
2.	Project title	Transition to responsibly sourced growing media use within UK Horticulture
3.	Contractor organisation(s)	RSK ADAS Ltd, Institute of Food Research and Stockbridge Technology Centre
4.	Project Leader	Dr Barry Mulholland
5.	Key staff: (name)	Dr Barry Mulholland
	(name)	Professor Keith Waldron
	(name)	Dr Henri Tapp
6.	Industry Representative	Dr Steve Carter
7.	Total AHDB project costs	£ 725,000
8.	Project: start date.............	01/01/2015
	end date	31/12/2019

9. **Please confirm your agreement for AHDB to publish this report. YES X NO**

(a) This report is intended for public consumption and as such it should be written in a clear and concise manner and represent a full account of the research project to date which someone not closely associated with the project can follow and understand.

AHDB recognises that in a small minority of cases there may be information, such as intellectual property or commercially confidential data, used in or generated by the research project, which should not be disclosed. In these cases, such information should be detailed in a separate annex (unpublished). Where it is impossible to complete the Interim Report without including references to any sensitive or confidential data, the information should be included and section (b) below completed. The expectation is that every effort will be made to provide a version of the report that can be published.

(b) If you have answered NO, please explain why the interim report should not be released into public domain

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Objectives

10. Please list the objectives as set out in the contract. If necessary these can be expressed in an abbreviated form, indicate where any amendments have been agreed with the AHDB project manager, with date.

Aims:

1. To construct a model that will produce the desired mixes at least cost.
2. To evaluate responsibly sourced growing media blends as alternatives to peat in commercial crop production systems.
3. By on-site demonstration and effective communication of the scientific evidence base increase grower confidence to facilitate the uptake of responsibly sourced growing media for commercial horticulture.

Objectives:

1. Determine the specific needs of each horticultural sector in terms of growing media requirements and match these against suitable raw materials and blends using appropriate methodology.
2. Identify and address, where practicable, any issues which may impact now and in the short to medium-term, on the suitability of the media in terms of availability, consistency, price, practical use on nurseries / farms and direct impact on production.
3. Examine the impact of the medium used throughout the whole supply chain (both retail and amenity) including, but not limited to, shelf-life and establishment after planting.
4. Formulate a programme of work via engagement with growers, growing media manufacturers (GMMs) and retailers to demonstrate the attributes of the media and to determine how they are best managed commercially.
5. Communicate any outcomes and conclusions to industry in a clear and concise way throughout the project via nursery / farm demonstrations, technical events, suitable publications, electronic media and other events as appropriate.

Project Progress Summary

11. The project summary should not ordinarily exceed 2 sides of A4 (approximately 1000 words) and should be understandable to the intelligent non-scientist i.e. growers and their advisors. Please highlight key messages as bullet points at the start of this section. It should cover progress since the last report and how this relates to the objectives. Provide information on actual results rather than just the activities. This can include a limited number of tables, charts figures etc. if deemed helpful. Description of methods and additional data etc. should be submitted in section 14

If there is something substantive to report that needs to be delivered to growers immediately then this section can be increased in size **if agreed with the project manager**

Headline

- A baseline for commercial proprietary growing media blends has been completed for physical properties.
- Current commercial peat / coir reduced and peat / coir free blends can perform similarly to host site standard mix controls, with greatest variation in performance detected in fast growing plant types e.g. herbs, bedding and vegetable propagation.
- Prototype blends that emulate peat "gold standard" physical characteristics have been developed by anonymised selection of any of the raw materials supplied by the growing media manufacturers (only the project team can develop the prototype mixes).
- Prototype mixes were tested under a range of nutrient and water regimes that represented commercial practice across a range of growing systems and selected plant types.
- Prototype mixes have produced commercially acceptable plants in tests conducted at ADAS Boxworth and STC.
- Prototype mixes will be brought forward to commercial trials in 2017.
- Further development and testing of prototype mixes will occur in 2017 for commercial trial evaluation in 2018.

Background and expected deliverables

CP138 '*Transition to responsibly sourced growing media use within UK Horticulture*' is a five year project[1] which will develop confidence in the use of new growing media materials to diversify a market that has been dominated by high performing peat products for many years. The pressure to seek other materials has come from a combination of government environmental policy and consumer preference for plant products produced in "peat alternatives". Commercially available growing media, other than peat, is grouped into four main raw material types: **coir**, **wood fibre**, **bark** and **green compost;** collectively and for the purposes of this project the four materials including peat are categorised as responsibly sourced growing media (**RSGM**). Over the last 20 years much progress has been made by the growing media manufacturers in the reliable sourcing and conditioning in sufficient quantities of each material. In some sectors such as soft and cane fruit then there has been a successful switch to coir from peat based growing media. Coir alone, however, is not suitable for all plant types and production systems and sufficient, high quality amounts at an affordable price could not be sourced to replace peat; furthermore, it would also again switch to a dependence on a single raw material type. It is appropriate on a sustainable availability, supply, performance and cost basis to blend up to four raw materials in a "blend",

[1] CP138 is a co-innovation project funded by Defra, AHDB Horticulture, Growing Media Manufacturers and Growers. The project is led by RSK ADAS Ltd with project partners The Institute of Food Research and Stockbridge Technology Centre.

to produce commercially acceptable “peat alternative” containerised plant products. In sectors which are the largest users by volume of growing media and where peat dominates (hardy nursery stock and bedding), growers have found that peat-reduced growing media, typically 25% other materials, can produce reliable and consistent results. Beyond this and towards 40-50% reduction can be described as “super reduced” and at this level and up to 100% peat free, then results have been variable, or just not suitable from a practical mechanisation and growing system perspective.

As an industry to make the cross sector leap beyond an average inclusion rate of 25% for materials other than peat then there has to be a reliable way to predict the performance of “peat alternative” blends. To date the only way to test 100% peat-free blends has been to conduct stand-alone trials. If, however, the raw materials change between testing and manufacture for supply then there can be some discrepancy between expected and actual commercial plant performance. To develop sufficient experience, knowledge and confidence in new material blends, then this can be time consuming. There is a need therefore to short-circuit this process and be able to reliably predict the performance of blends at the point of manufacture; this is the main deliverable of CP138. If this can be achieved then it will not only increase the range of materials that can be sourced and used by the horticulture industry but expedite the uptake of new materials that can perform as well or better than the industry standard, peat.

This will be achieved through a programme of targeted research and development, knowledge transfer, demonstration trials and dissemination of best practice throughout all the relevant horticulture sectors (**Figure 1**). The project includes all commercial horticulture sectors where growing media is currently used including, but not limited to: vegetable and salad propagation, protected edible crop production, mushroom production, soft fruit propagation and production, top fruit propagation and production and ornamentals propagation and production (including container-grown plants and bulbs).

The key features of the project are summarised as follows:

- Five year co-innovation project, funded by Defra, GMMs, AHDB and growers to move towards increased use of RSGM (wood fibre, bark, coir and green compost).
- The work represents commercialisation of previous Defra funded work e.g. HortLINK CP23, CP50 plus two DTI grants and numerous HDC/AHDB funded projects.
- The key deliverable is a model which will predict the performance of RSGM raw material blends.
- Data will be used to provide the evidence base to select for a range of cost effective high performing RSGM blends.
- CP138 will facilitate experimental and large-scale grower hosted trials to quantify RSGM performance for all sectors of horticulture.

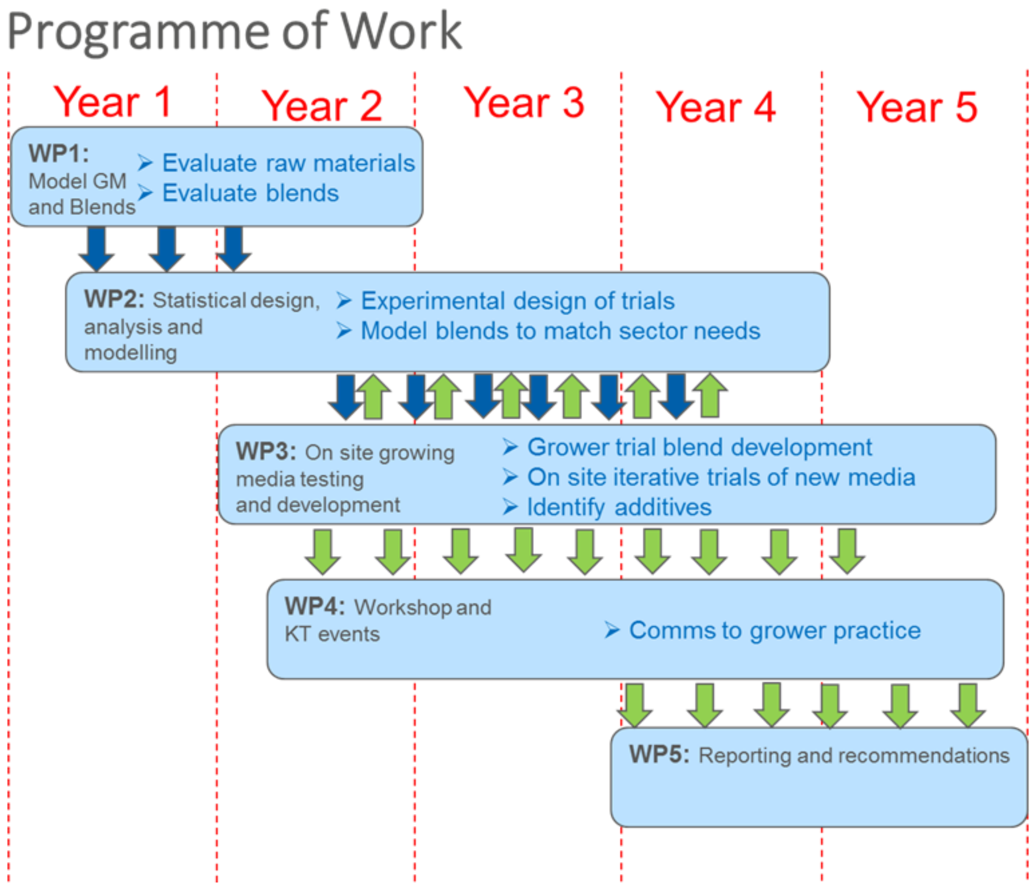


Figure 1. Programme of work across the 5 year project. **Work Package 1** is near completion, **WP2, 3** and **4** have begun and will run throughout the project. Each WP consists of a number of agreed specific tasks.

Summary of findings

The main activities and outputs for **WPs 1, 3** and **4** will be described in the following sections. **WP2** is integral to all practical work carried out in **WP1, 2** and **3**, as experimental design, data analysis and modelling are core to the experimental work and the production of robust data that can be used to inform practice in the selection and use of growing media.

WP1: *Characterise growing media blends for each sector, parameterising MVM model, grower sites and key experiments* ***(Tasks 1.2-1.3).***

Methodology

Selected physical and chemical parameters were completed for all raw materials supplied to the project by the growing media manufacturers; the methodology was published in a technical monograph (Mulholland BJ, Waldron K, Bragg N, Newman S, Tapp H, Hickinbotham R, Moates G, Smith J, Kavanagh A, Marshall A, Whiteside C, Kingston H (2016) Technical Monograph: Growing Media Laboratory Methods. ISBN 978-1-5262-0393-9, 25 pp., available at: http://www.adas.uk/Portals/0/Documents/Technical%20Monograph%20Growing%20Media%20Laboratory%20Methods.pdf.) This was an important output for the project as it provides the first published update on detailed methodology for materials other than peat. The techniques also promote growing media analysis excellence which is critical for the introduction of new materials and the continual development of high performing and affordable growing media products. It allowed the development of the centroid approach to quantify the position of peat in relation to all other materials sourced based on the triangulation of three key physical parameters; available water (AW), dry bulk density (D_b) and air filled porosity (AFP) (**Figure 2**).

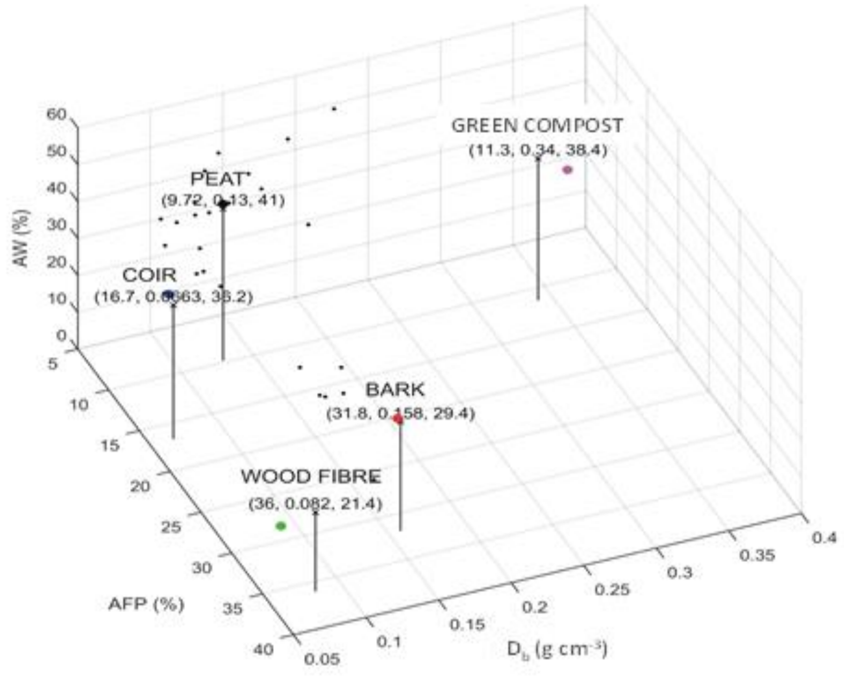


Figure 2. Stems marking the position of the average physical properties are the "centroid" for peat, coir, bark, wood fibre and green compost. The position of all of the peat samples are shown as black dots. For peat, there is a main cluster, and a second smaller cluster which have properties similar to bark. The 'stem' for peat marks the average of the selected properties for the main peat cluster. The position of individual samples (coloured symbols) that have properties close to the average values for each raw material type, are also shown. On the axes **AW**, **AFP** and $\mathbf{D_b}$ denote respectively available water, air filled porosity and dry bulk density.

Both physical and chemical properties were measured for raw materials (**Table 1**Error! Reference source not found.**; Task 1.2.4**). Physical properties are inherently more stable and can be less easily changed once they are placed in a containerised growing system. Chemical properties at this stage in the project provide a way to screen raw products for potentially high levels of nutrients that could cause toxicity or an imbalance in supply to selected growing material. As the project develops then these data could be used to further refine the performance characteristics of designed growing media blends. Detailed nutrient analysis summaries can be located in the technical monograph (http://www.adas.uk/Portals/0/Documents/Technical%20Monograph%20Growing%20Media%20Laboratory%20Methods.pdf.). The approach to focus on physical properties continues the development work established in DTI (HortLINK, HL0179 and HDC projects CP 23 and CP 50), which explored the use of controlled composted waste as a growing media.

Table 1. The range of chemical and physical properties for each selected RSGM raw material type.

Raw material	pH	EC (µS cm^{-1})	CEC (meq 100 cm^{-3})	AFP (%)	Available water (%) at 5kPa	Dry bulk density (g cm^{-3})
Coarse peat (10-25 mm)	4.2 - 4.7	15.0 – 49.0	15.1 - 42.8	13.3 - 38.4	32.5 – 44.6	0.12 - 0.19
Fine peat (0-5 mm)	4.1 - 4.7	24.2 - 49.8	10.5 - 20.9	8.2 - 9.1	35.0 – 43.0	0.09 - 0.17
Bark (0-8 mm)	5.7 - 6.4	98.0 - 246.1	13.9 - 22.0	16.3 – 26.3	30.1 - 34.2	0.16 - 0.23
Potting bark (5-16 mm)	5.3 - 5.8	20.2 - 46.3	7.3 - 11.9	38.6 - 49.4	35.0 - 43.0	0.15 - 0.17
Buffered coir (0-12 mm)	6.9 - 7.3	38.3 - 96.2	5.3 - 6.8	17.3 - 20.3	36.6 - 40.4	0.06 - 0.11
Green compost (0-10 mm)	7.5 - 8.2	456.6 - 1739.1	15.8 - 20.9	5.0 - 15.1	35.8 - 46.7	0.23 - 0.52
Wood fibre (all tested types *)	5.4 – 8.3	5.3 – 441.1	9.0 - 14.9	25.4 - 51.7	13.2 – 24.7	0.06 - 0.11
Vermiculite (superfine-medium)	8.0 - 9.8	18.7 - 36.7	3.0 - 9.7	11.9 - 40.2	34.4 - 41.6	0.10 - 0.13
Perlite (fine-coarse)	8.0 - 9.2	5.2 - 9.7	0.8 - 2.1	21.3 - 36.2	21.4 - 24.2	0.05 - 0.12

* Wood fibre includes medium and coarse, steam extruded and mechanically extruded samples.

Prototype blend development

The physical properties of blended growing media were evaluated in a 22 point mixture experiment (**Task 1.2.3**), with selected ratios of bark, coir, green compost and wood fibre, mixed in 1, 2, 3 or 4 component mixes. Importantly, and so that the project team could select components for the best blends on an anonymised basis, then any of the raw materials could be used in the blending experiment. This meant that no one growing media manufacturer could replicate the mixes; it was the development of knowledge that was key and important for the industry to know how to emulate high performing blends using the methodology developed in CP138. Three physical parameters were selected by observed goodness of fit to the peat centroid established from the analysis of raw materials (**Figure 2**). The idea of the experiment was to understand whether we were able to emulate the peat centroid from combinations of other raw materials (**Figure 3**). Mixes that came close to peat and that were selected for testing with plant material were either two or three component blends and are the turquoise symbols; an outlier was also selected that would be considered to be poor performing and was located some distance from the peat centroid (**Figure 3**). Two "super mixes" were tested (green symbols), but these were not taken forward as the materials could not be easily and reliably sourced in commercial quantities by the growing media manufacturers i.e. they were not representative, and furthermore, chemical analysis revealed that the coir sourced for the “super mix” had a relatively high Cl content. The four mixes taken forward for testing, three of which came close to the peat centroid with a single outlier, encapsulated selected combinations of each of the peat alternative materials identified for inclusion in CP138; coir, bark, wood fibre and green compost. The results of testing with selected plant material are reported in **WP3**.

The baseline to compare the prototype mixes against, was developed from physical property testing of the proprietary mixes used in commercial trials for 2016 /17 (**Figure 4**). The commercial mixes were peat or coir, peat / coir reduced and peat / coir free formulations. The mixes broadly mapped onto commercially available peat products (**Figure *4***; black dots; **Tasks 1.2.3.1** and **Task 1.2.3.2**) and apart from products selected from HNS and strawberry production were in the high available water region (40-60%) with AFP and D_b in the range 7-15% and 0.1-0.2 gcm^{-3} respectively. The prototype mixes were however at the low end of the available water scale 20-30%, which has implications for water management and which has been tested for **Task 1.3** and in **WP3**. The next phase of the work to be completed by 31 March 2017 (**D11-12**) will assign key plant performance indicators against growing media physical parameters to quantify the relationship between growing media blend and commercial product. This will be an important step in the development of the model as a selection tool for high performing blends.

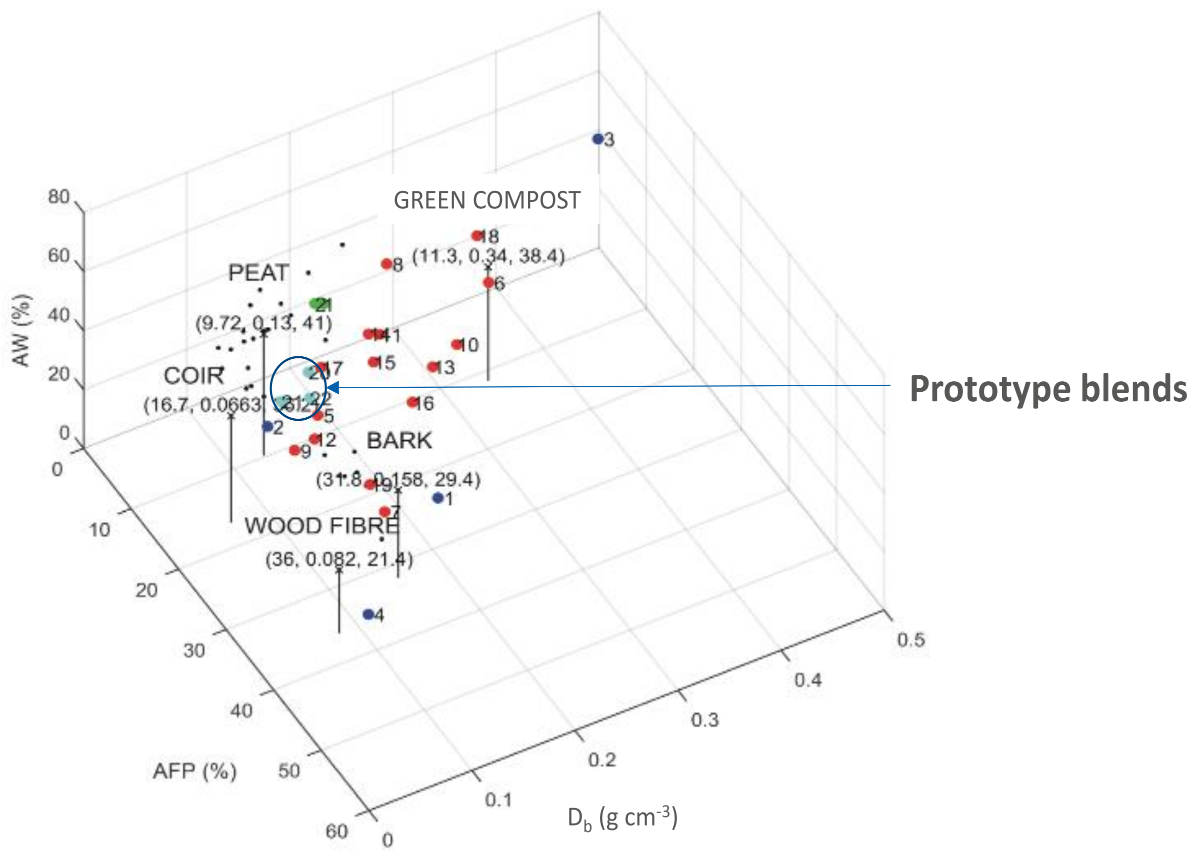


Figure 3. Physical propertied of the mixtures: blue symbols, pure components; stems, location of the pure component centroids; red symbols, main mixtures; turquoise symbols, coir rich 3-component blends (Mix20-22) which were selected for prototype blend evaluation; black symbols, peat; and green symbols, ‘Super-Mixes’ which were sourced from “non-typical” bulk sourced raw growing media materials.

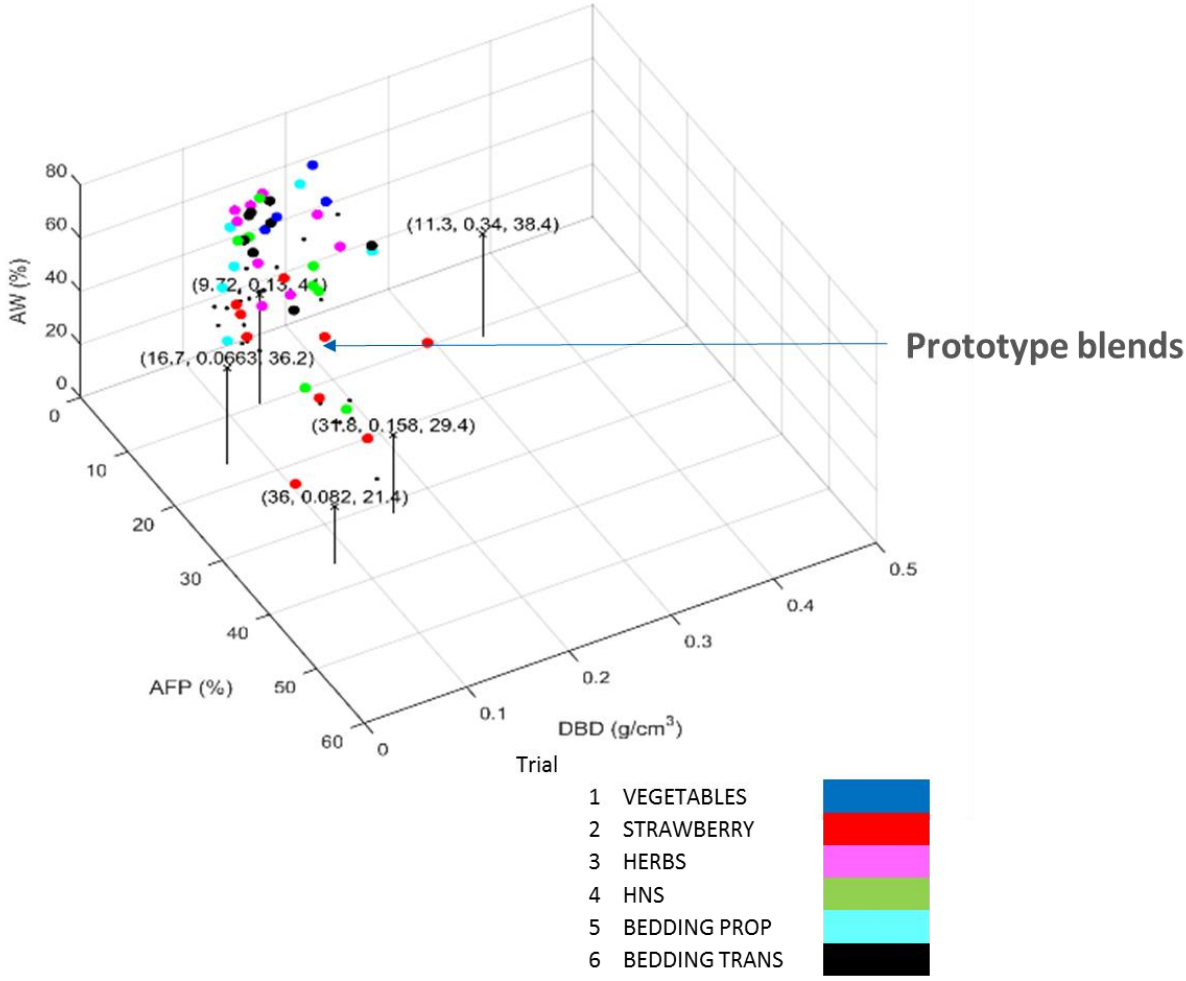


Figure 4. Physical properties of the proprietary growing media blends used in 2016 commercial trials on grower hosted sites. The data indicate that the spread of values broadly cover peats available from the growing media manufacturers (black dots)and that apart from some strawberry and HNS mixes products are in a relatively tight range for AFP (7-15%) and bulk density (D_b: 0.1-0.2 g cm^{-3}). Available water produced the greatest range of 20-60%, with many products populating the high available water range. Interestingly the prototype mixes were in accordance with commercial products AFP and D_b, but were at the low end for available water. This differentiation produced some positive differences for plant performance linked to growing media physical properties, water availability and atmospheric conditions cf. bedding plant summary report.

WP3: *On-site growing media testing and development*

During 2016, trials were conducted both on grower sites and at the experimental sites of ADAS Boxworth and Stockbridge Technology Centre (**WP3**, **Tasks 3.1.1**-**3.1.9**). Each trial has been summarised below, and further information can be found in the Appendices.

<u>Proprietary growing media testing – grower hosted sites</u>

During 2016, trials were carried out on five grower sites (**Table 2**). Each trial consisted of one peat-reduced and one peat-free blend from each of the growing media manufacturers (GMMs), plus the nurseries standard product as a control, resulting in nine treatments per trial. As coir is already used as standard in strawberry production, the trial blends here consisted of either coir-reduced, or coir-free. This was done to provide baseline information for current blends, which future growing media mixes can be tested against using the physical properties framework methodology. Each GMM was assigned a code (A, B, C or D) to ensure that products remained anonymous throughout the project. Prior to the trials commencing, nutrition levels for each crop were agreed with the host grower, so that each trial blend had the same concentration of nutrients applied at a set pH, so that any observed differences were due to the growing media blend and not nutrient availability. The growing media supplied were also tested for physical and chemical properties to understand how plant performance can be related to these properties.

Table 2. Grower hosted trials in 2016.

Host	Trial	Duration
Bordon Hill	Bedding	Sown week 16 - 17, transplanted week 23
G’s	Lettuce Spring	Sown week 14, harvested week 26
G's	Lettuce Early summer	Sown week 26, harvested week 35
G's	Lettuce Late summer	Sown week 32, harvested week 43
New Farm Produce	Strawberries	Planted week 12. Overwintering into 2017
Vitacress	Herbs Spring	Sown week 13, harvested week 20
Vitacress	Herbs Summer	Sown week 31, harvested week 37
Vitacress	Herbs Autumn	Sown week 42, harvested week 48
Wyevale	HNS Finals	Planted week 13 – 20. Overwintering into 2017
Wyevale	HNS Liners	Planted week 16 – 22. Overwintering into 2017
Wyevale	HNS Propagation	Planted week 45. Overwintering into 2017

Protected Ornamentals – Bedding

Trials were carried out on both propagated and transplanted material of *Begonia Semperflorens* Heaven Red and Pansy Matrix Yellow Blotch, from 21 April 2016 to 07 July 2016. Propagation was carried out at Bordon Hill Nurseries Ltd (Stratford-upon-Avon, CV37 9RY) and transplanting was completed at Baginton Nurseries (Coventry, CV8 3BA). In each trial, nine growing media treatments were used (**Appendix 1**). Seeds were sown into 230-cell trays, and propagated as per commercial practice. Germination and plant growth was monitored, and plants were assessed in week 22, just prior to transplanting, for plant height (10 plants per plot), transplant quality (scale 1-3), root development (scale 0-4) and pullability (how well the plug holds together - scale 1-3). For scoring criteria see **Appendix 1**.

Plants were transplanted into standard 6-packs, using corresponding peat-reduced or peat-free pack-bedding blends from the four GMMs, and grown on until week 27, when a final marketing assessment was completed (**Appendix 1**). Plants were assessed for height (four plants per plot), quality (plot overall score, 0-3) and number of plants per plot in flower.

During the propagation stage, germination of both the Pansy and *Begonia* was relatively even, and with the Pansy, there was little difference in the size of the young plants (**Figure 5**). Differences were more noticeable in the *Begonia*, plants grown in treatment 8 (peat-free) appeared to stop growing soon after germination, and were still small at transplant (**Figure 6**). Generally, the peat-reduced treatments were better during propagation, and produced plants that were even in size.

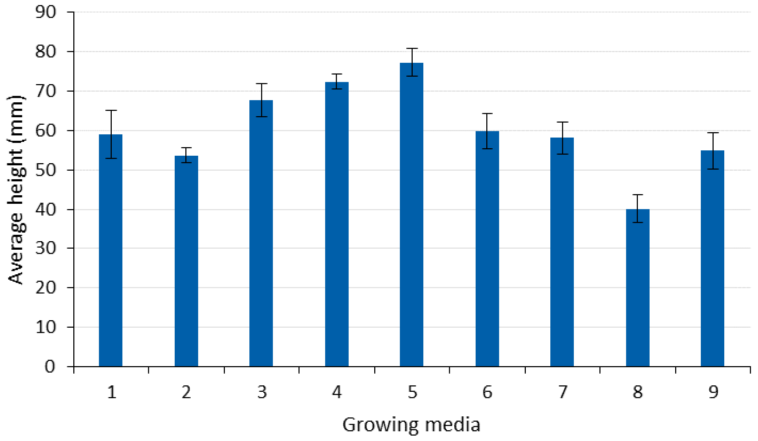


Figure 5. Pansy mean height (mm) for the nine growing media blends at transplant stage (week 22). Differences across treatments are statistically significant ($p < 0.001$). Error bars represent 2 standard errors, with 8 degrees of freedom (d.f.)

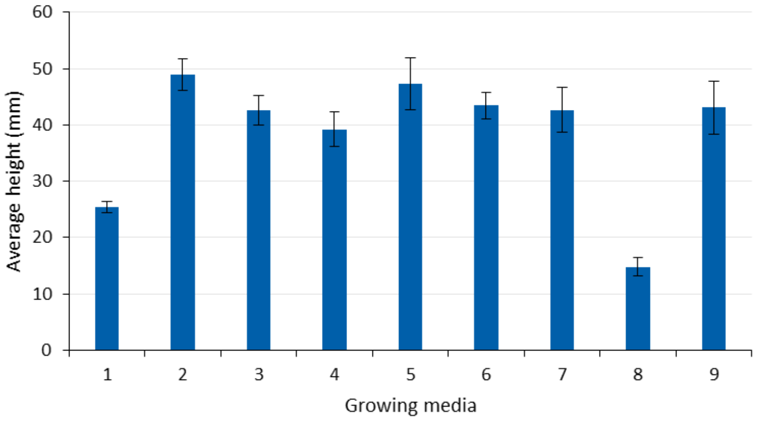


Figure 6. *Begonia* average height (mm) for the nine growing media blends at transplant stage (week 22). Differences across treatments are statistically significant ($p < 0.001$). Error bars represent 2 standard errors, with 8 degrees of freedom (d.f.)

In terms of plant quality at transplant, and final marketability, the majority of the growing media treatments performed as well as the nursery peat control.

The pansies grown in the peat-reduced growing media were significantly taller at transplant stage than the control plants. With the exception of one treatment, the peat-free growing media treatments produced plants that were a similar size to those grown in the nursery control peat. This has potential implications for the need to use plant growth regulators in peat-reduced growing media. It may also suggest that plants grown in peat-reduced growing media may require less time to reach transplant stage.

The plants in one of the peat-free treatments (treatment 8) performed poorly at the transplant stage for both Pansy and *Begonia*, producing *Begonia* plants that would not have been suitable for transplant. The poor performance of growing media treatment 8 was seen across all of the assessments of the *Begonia* at transplant stage, however the differences were only significant for the plant height and the transplant quality score.

Once plants had been transplanted into 6-packs, the growth and development began to even out, and by week 27, the target market week, the Pansy plants were of a similar quality, and all of the treatments were in flower (**Figure 7**). With the *Begonia*, the plants grown in treatment 8 remained small, and there were less plants in flower in week 27, although they had started flowering (**Figure 8**).

Figure 7. Pansy Matrix Yellow Blotch, week 27 – control (left), peat-reduced (middle) and peat-free (right)

Figure 8. *Begonia semperflorens* Heaven Red, week 27 – control (left), peat-reduced (middle) and peat-free (right)

Field vegetables – Lettuce propagation and production

Trials on iceberg lettuce propagation (cv. Challenge), were carried out at G's Growers Second Willow Nursery (Ely, CB6 1EF), during spring, early summer and late summer (**Table 3**). Only two of the GMMs supplied blends for the trial, as vegetable and salad propagation is quite a niche market. There were eight peat-reduced treatments, which contained various quantities of coir and bark as the peat substitute, plus a 100% peat control supplied by G's, and a blend containing peat and digestate, also supplied by G's (**Appendix 2**). The blends were mixed with water in order to form the blocks into which the seeds were then sown. Seeds were allowed to germinate in a germination room for 2-3 days, before being placed in the glasshouse. Once plants had reached 1-2 true leaves, the trial was assessed for plant height (10 plants per plot), transplant quality (scale 1-3) and fresh and dry weight (combined weight of 10 plants per plot). For scoring criteria see **Appendix 2**. Observations were also made on root development and the friability of the blocks. A sub-sample of plants were then planted into the field, among a commercial crop, and grown on to harvest (**Figure 9**). At harvest, yields were assessed, along with quality (scale 1-3), head development and the number of internal leaves (**Appendix 2**).

Table 3. Sowing, transplant and harvest dates in spring, early summer and late summer trials 2016.

Trial	Sowing date	Transplant date	Harvest date
Spring	Week 14	Week 18	Week 26
Summer	Week 26	Week 28	Week 35
Autumn	Week 32	Week 34	Week 43

Figure 9. Lettuce trial set out in the glasshouse (left) and being planted out in the field (right)

In terms of lettuce germination and initial growth, there was very little difference between the majority of the growing media treatments for each of the trials. All treatments germinated at the same time, and when germination assessments were completed, only treatments 3 and 7 (with a higher proportion of bark) were smaller, with some trays showing uneven germination. It is possible that this was related to nutrition, and the bark blends may have required liquid feeding at an earlier stage.

When the plants were assessed prior to transplanting, most of the growing media treatments performed as well as the nursery peat control in terms of plant quality throughout the three trials. In all of the trials the blends with the highest proportion of bark (treatments 3 and 7) produced the shortest young plants, which was often accompanied by low fresh and dry weights and poorer quality. Treatment 3 in the spring sowing produced the poorest quality plants across all three trials and these plants would not have been planted into the field commercially (**Figure 10**).

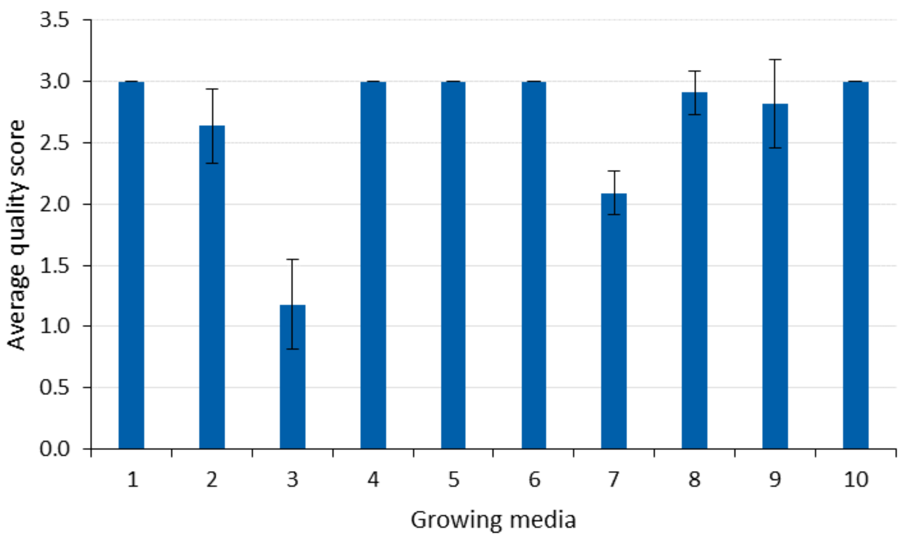


Figure 10. Lettuce average transplant quality score for the 10 growing media blends at transplant stage (week 18). Differences across treatments are statistically significant ($p = 0.026$). Error bars represent 2 standard errors, with 9 degrees of freedom (d.f.)

In the spring trial the differences seen at the transplant stage were carried out into the field, with treatment 3 producing lighter lettuces with fewer leaves on average per head. These lettuces were found to have large gaps between the leaves and a looser structure than the other treatments. The differences seen in the lettuces heads in the spring trial were not present in the early summer or late summer trials. It is possible that the cool spring temperatures may have been the reason for this.

Of particular concern for the nursery was i) how well the blends would hold together in order to produce the initial blocks and ii) how the peat-reduced blocks would handle in the planting machinery. On arrival at the nursery, the blends were all drier than the nursery standard peat, and in particular, the peat/coir blends were very dry. Each blend had to be mixed with water by hand, until it was of a suitable consistency to pass through the blocking machinery, and form the blocks. Whilst the plants were on the nursery, all treatments were watered the same, and there didn't appear to be any issues with the growing media drying out.

At transplant, the blocks were checked to see how well they held together. There was a very small amount of crumbling from each of the treatments, however, this didn't cause any issues at planting, and the blocks were able to pass through the planter with ease.

For the spring and early summer trials, there was little difference in yield and quality between the control and the treatments, although one of the peat/bark blends was much smaller than the other treatments. In the late summer trial, the majority of the treatments were below the specification of 450 – 500 g head weight. This may have been due to planting date, and the fact that with day length decreasing, the treatment plants simply required a longer time to grow.

Protected edibles – herbs

Trials on basil, coriander and parsley were carried out at Vitacress Herbs in spring, summer and autumn 2016 (**Table 4**). Nine growing media treatments were used for each trial, which was grown within a commercial crop (**Appendix 3**). Seeds were sown into round, 10.5 cm pots and plants were watered overhead until germination, and then fed and watered via an ebb and flood system (**Figure 11**). Germination, plant growth and root development was monitored, and a final assessment was carried out at marketing, for quality (scale 1-3), height, fresh and dry weight. For scoring criteria see **Appendix 3**.

Table 4. Sowing and harvest dates for each species in spring, summer and autumn 2016.

Trial	Sowing date	Harvest date
Spring – basil	Week 13	Week 19
Spring - coriander	Week 15	Week 19
Spring – parsley	Week 13	Week 19
Summer – basil	Week 31	Week 35
Summer – coriander	Week 32	Week 35
Summer - parsley	Week 31	Week 35
Autumn – basil	Week 42	Week 48
Autumn – coriander	Week 43	Week 48
Autumn - parsley	Week 42	Week 48

Figure 11. Basil pots placed 'pot-thick' on the ebb and flood bench (left) and then after spacing (right)

Pots were monitored for germination, and for each species at each sowing date, there was very little difference in both germination time and the number of seeds that germinated within each pot, between the growing media treatments.

During the main growth phase, the roots were examined and there was little difference in root development between any of the growing media treatments. Each species had plenty of clean white roots which were visible at the base of the pot.

It was noted during all trials that some of the peat-free treatments, treatment 7 and 9, were slower to grow, and were shorter than the other plants. Once the trial reached harvest, however, these plants had generally caught up and reached the specified height.

In the spring trial, treatment 7 (peat-free) produced the lightest plants in all three species, and the shortest parsley crop (**Figure 12**). Quality was not affected by any of the treatments for the coriander or parsley spring crop, although the basil crop quality was slightly reduced by treatment 2 and 3, peat-reduced and peat-free. Interestingly, in the spring basil crop, all of the treatments apart from 2 and 3 produced plants that were of a higher quality (leaf quality and colour) compared with the control.

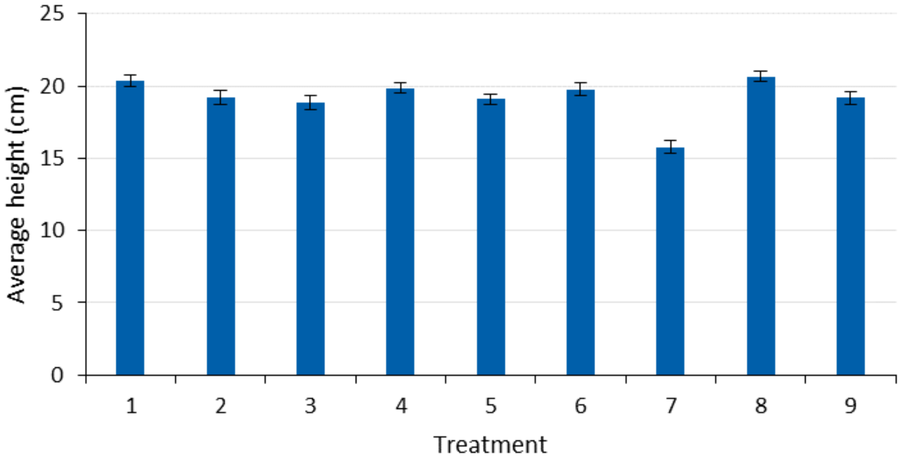


Figure 12. Parsley average height (mm) for the nine growing media blends in the spring sowing at harvest (week 19). Differences across treatments are statistically significant ($p < 0.001$). Error bars represent 2 standard errors, with 8 degrees of freedom (d.f.)

In the summer trial, treatment 9 (peat-free) produced the lightest and shortest coriander crop, and this crop did not reach the height specification of 15 cm (**Figure 13**). Treatment 9 was also one of the lightest basil crops, along with treatment 2 and 3, which were also the shortest crops. Quality was not affected by any of the treatments for any of the species, and the parsley was not significantly affected in any of the areas that were assessed.

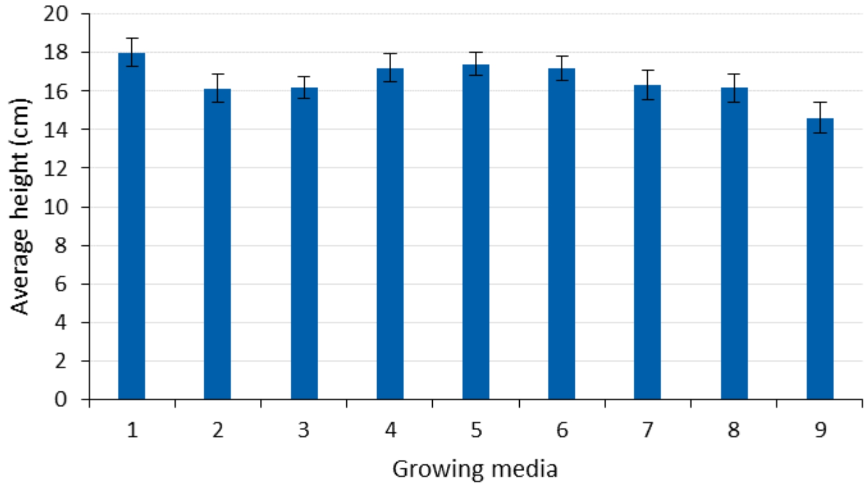


Figure 13. Coriander average height (cm) for the nine growing media blends in the summer sowing at harvest (week 35). Differences across treatments are statistically significant (p = 0.018). Error bars represent 2 standard errors, with 8 degrees of freedom (d.f.)

In the autumn trial, treatment 7 (peat-free) produced the lightest and shortest plants in all three species. However, the parsley and coriander grown in treatment 7 did reach the 15 cm height specification, whereas the basil grown in treatment 7 did not (**Figure 14**). Treatments 2 and 3 (peat-reduced and peat-free) were also some of the lightest plants for all three species.

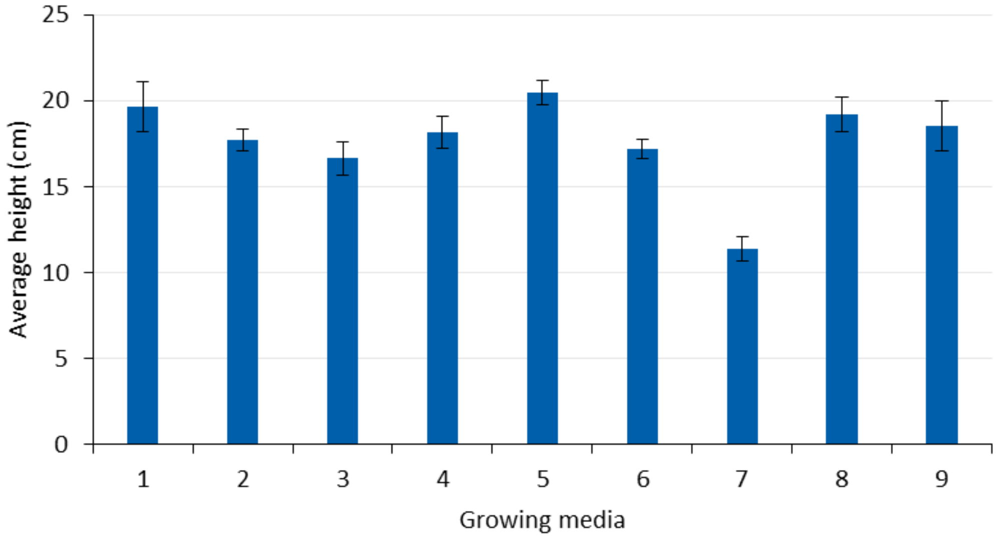


Figure 14. Basil average height (cm) for the nine growing media blends in the autumn sowing at harvest (week 48). Differences across treatments are not statistically significant (p = 0.060). Error bars represent 2 standard errors, with 8 degrees of freedom (d.f.)

Although the pots were grouped on benches by treatment type (i.e. peat-reduced or peat-free) to allow for different watering needs, the water requirement of the different media was not as different as was originally expected. Therefore, the treatment plots were watered the same as the control.

Soft fruit – strawberries

This trial was conducted at New Farm Produce (Lichfield, WS13 8EX) using the strawberry variety Malling Centenary and nine growing media treatments (**Appendix 4**). Troughs were filled with the relevant growing media and planted in week 12. One row of both coir-reduced products and coir-free products were planted with tray plants (i.e. a plant that has already developed in compost) and the other six rows were planted with bare root plants (**Figure 15**).

Figure 15. Strawberry trial set up at New Farm Produce, week 18

The plants were watered and fed by a dripper system, with two dripper heads per trough. All troughs had the same feed and nutrient regime. Picking of the trial commenced in week 23 (7 June 2016) and continued twice weekly until week 28 (final picking date was 13 July 2016). The weight of Class 1 and Class 2 fruit, as well as the total fruit weight were measured at each picking date. Detailed assessments, including fruit Brix levels were carried out on one tray plant and one bare root plant row from each section (i.e. two coir-free rows and two coir-reduced rows). Slumping of the growing media and yields will be assessed in 2017.

Overall, the different growing media treatments had more of an effect on the tray plants than the bare root plants. Whilst there were no significant differences in the total yield of the bare root plants, there were differences in the tray plants, with all but one of the coir-free treatments producing lower yields compared with the coir control (**Figure 16**).

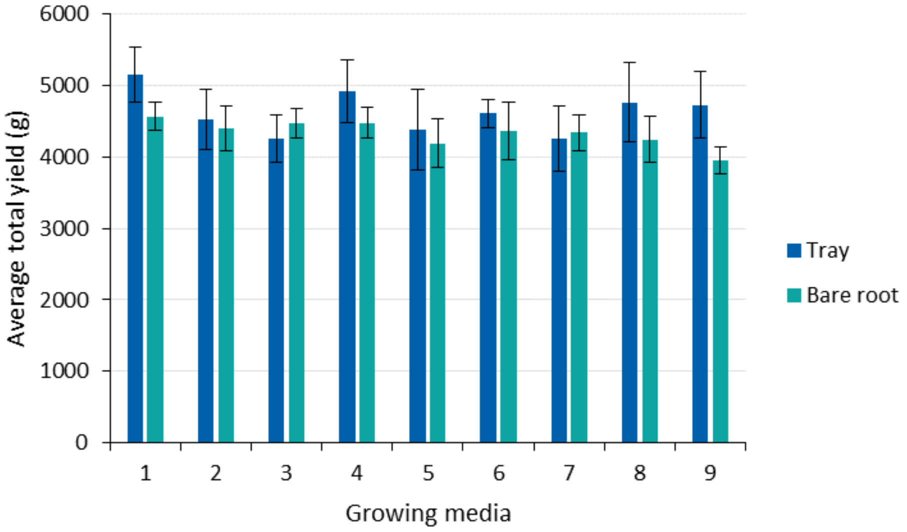


Figure 16. Average total strawberry yield (g) for the nine growing media blends for the whole of the picking period. Differences across treatments are statistically significant for tray plants ($p = 0.006$), but not for bare root plants. Error bars represent 2 standard errors, with 8 degrees of freedom (d.f.)

The bare root and tray plants did not perform as well in the coir-free media compared with the standard coir product, however the bare root plants had the lowest yield in treatment 9, whilst the tray plants had equally low yields in treatments 3, 5 and 7.

The tray plants produced a greater yield more quickly compared with bare root plants, except in the three poorer performing coir-free treatments. In these treatments the tray plant yields throughout the picking dates were comparable to the bare root plants and they all achieved a similar total yield. This demonstrates that even if plant material is used that should be able to become established more quickly, this will not necessarily occur if the growing media used is not optimal.

The tray plants had greater total yields than the bare root plants, however, the percentage of Class I fruit was consistently higher in the bare root plants when compared with the tray plants in each growing media treatment (**Figure 17**).

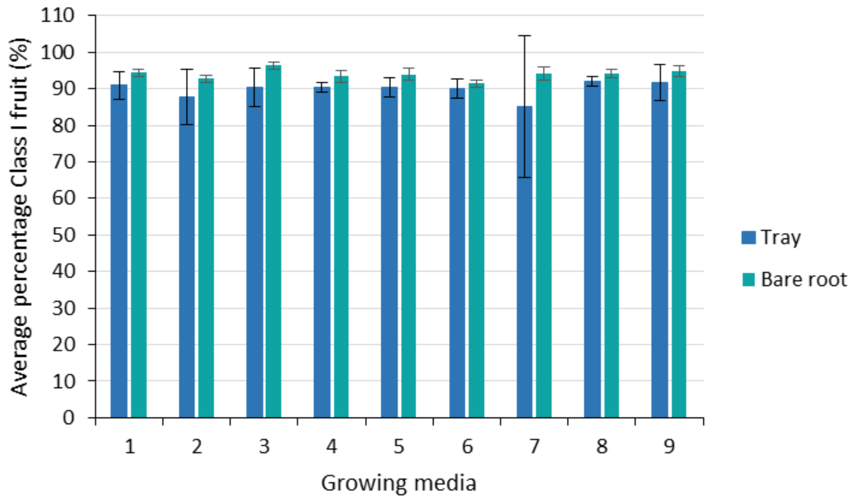


Figure 17. Average total Class I strawberry yield (g) for the nine growing media blends for the whole of the picking period. Differences across treatments are statistically significant for both bare root and tray plants ($p = 0.048$ and $p = 0.022$, respectively). Error bars represent 2 standard errors, with 8 degrees of freedom (d.f.)

Hardy Nursery Stock

Trials were carried out at Wyevale Nurseries (Hereford, HR4 7AY) on a number of species, as both liners, finals and propagated material, during 2016 (**Table 5**). A total of nine growing media treatments were used in each trial, and the nutrition was tailored to suit each species (**Appendix 5**).

Table 5. Planting dates for the various species used in the liner, final and propagation trial in 2016

Species	Liner planting week	Final planting week	Propagation planting week
Berberis Darwinii Nana	16	16	N/A
Choisya ternata	22	16	45
Euonymus fortunei Silver Queen	18	20	45
Euonymus japonicus Green Rocket	18	20	45
Fuchsia Tom Thumb	N/A	13	N/A
Viburnum davidii	22	13	45

Plants were monitored for growth and root development and the *Fuchsia* finals were assessed in week 27 when they were commercially marketable. The remaining liners and finals trials were assessed in week 44 to determine plant quality and potential marketability (scale 1-9). For scoring criteria see **Appendix 5**.

For finals and liners, the majority of the growing media treatments performed as well as the nursery 25% peat-reduced blend in terms of plant quality for all hardy nursery stock species. In the finals there were no differences in the quality of the plants produced in any of the growing media treatments. Whilst there were some quality issues in the *Choisya ternata*, this was prevalent across all of the growing media treatments, including the control, and was not related to the growing media treatments.

The only plant species that showed any significant difference in plant quality was that of *Berberis Darwinii* 'Nana' in the liner pots (**Figure 18**). One peat-free treatment showed a significant quality reduction compared to the other treatments, however the plants were still of excellent saleable quality. When potted on to finals in 2017, further differences in quality may be noted between the treatments.

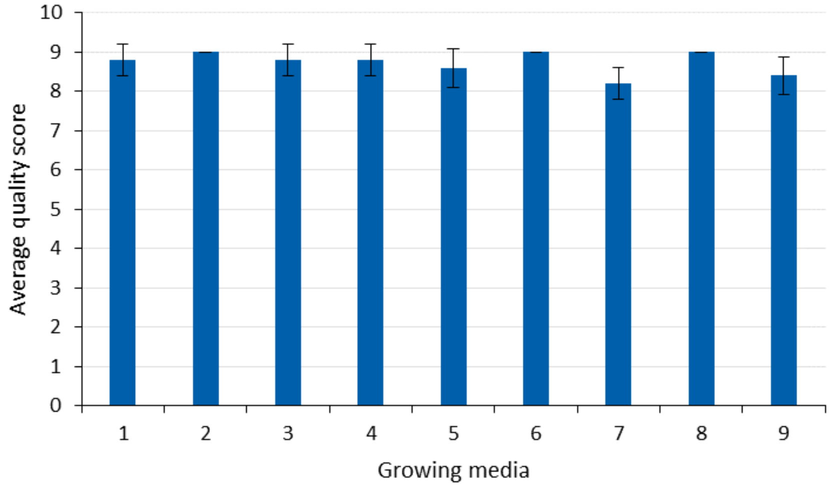


Figure 18. *Berberis Darwinii 'Nana'* average quality score for the 9 growing media blends in week 44. Differences across treatments are statistically significant (p = 0.017). Error bars represent 2 standard errors, with 8 degrees of freedom (d.f.)

Growing on the plants into the 2017 season should increase the knowledge of how the whole nursery production line quality will be influenced by the use of peat-reduced and peat-free media throughout the process.

Conclusions

Overall, there was very little difference between any of the growing media treatments when compared to the nursery control in the 2016 proprietary blend grower hosted trials. For bedding and herb production, there was one peat-free blend which did not perform as well as the others, and plants were generally of a poorer quality. The observed effects were possibly linked to nutrient availability and analysis of growing media samples (to be completed) will provide additional data with which to interpret plant performance. Similarly with lettuce production, blends with the highest proportion of bark visibly produced plants of a poorer quality, however if liquid feeding had been introduced earlier, the quality may well have been maintained.

All grower hosted trials were set out in a restricted randomisation, keeping the peat-reduced and peat-free treatments separate, as there was concern that the different media may need managing differently, and this would not be possible with a full randomisation. However, during the trials, the media were all watered in the same way, and there did not appear to be any issues with the peat-free media drying out more rapidly than the peat-reduced media.

Prototype blends testing – experimental sites

Following on from the prototype blend mixing experiment described in **WP1**, the three blends most similar to peat in terms of physical properties were selected for use in experimental trials in 2016. As well as these prototype blends, an outlier blend was selected to demonstrate that this modelling approach was appropriate and all of the blends were tested against a 100% peat control. These blends, plus the control, were tested at Stockbridge Technology Centre (STC) and ADAS Boxworth in 2016 on various plant subjects, to determine their suitability for use on grower holdings in the subsequent year.

The trials at ADAS Boxworth were irrigated and liquid fed using a bespoke Priva system using a range of water delivery systems. Having consulted with growing media manufacturers and growers, two target nitrogen (N) concentrations (high and low) and irrigation rates (high and low) were selected. For the N concentrations, 250 ppm N and 100 ppm N were selected as high and low values (**Appendix 6**). These values were guided by the range of plants that would be tested during the trials and were fixed for all plant trials. The high and low irrigation rates were guided by the nurseries providing the plants and were adjusted depending on the weather and plant need. The majority of the trials were tested with the five growing media blends, two irrigation rates and two target N concentrations, totalling 20 treatments (**Appendix 6**). The hardy nursery stock trial at STC used the same target N concentrations as ADAS Boxworth, with a single irrigation rate.

Protected Ornamentals – Bedding

The trial was conducted in the polytunnel testing facility at ADAS Boxworth using two species of bedding plants; *viola* and *dianthus*. Plug plants were supplied by Ivan Ambrose & Co Ltd (Liverpool, L31 4JD) in week 27, and were transplanted into four-pack bedding plant trays filled with the relevant growing media on 08 July 2016.

Two benches were used for this trial, one for each species. Each bench was split into four sections, with each section measuring 1200 mm by 1900 mm. These sections were separated by Perspex to avoid any splash from other sections and the bench itself was covered in capillary matting with micro-perforated plastic film on top.

Plants were irrigated and liquid fed overhead via mist sprinkler using the Priva irrigation system. The plants were irrigated twice per day during very warm weather, this was reduced to once per day as the weather cooled (

Appendix 7). A total of 20 treatments were used in this trial, these comprised of five growing media, two nitrogen levels and two water levels (**Appendix 6**). Once the plants reached maturity (week 31, 5 August) all were assessed for quality (scale of 1-3), plant height, numbers of plants in flower per pack and root quality score (scale of 0-4). For scoring criteria see

Appendix 7.

There was a significant difference in the quality of the *viola*s across the treatments in this trial (p < 0.001, d.f. = 19) (**Figure 19**). Pansy Mottle Syndrome (PaMS) was recorded in some of the treatments, which may have related to the wetness in those treatments (). The PaMS symptoms may have also coincided with particular atmospheric conditions such as high temperature and high vapour pressure deficit (drying atmosphere). This is currently being investigated as part of another project (PO 016 and PO 016a) and hopefully the data from this work will add to the output from the PaMS project.

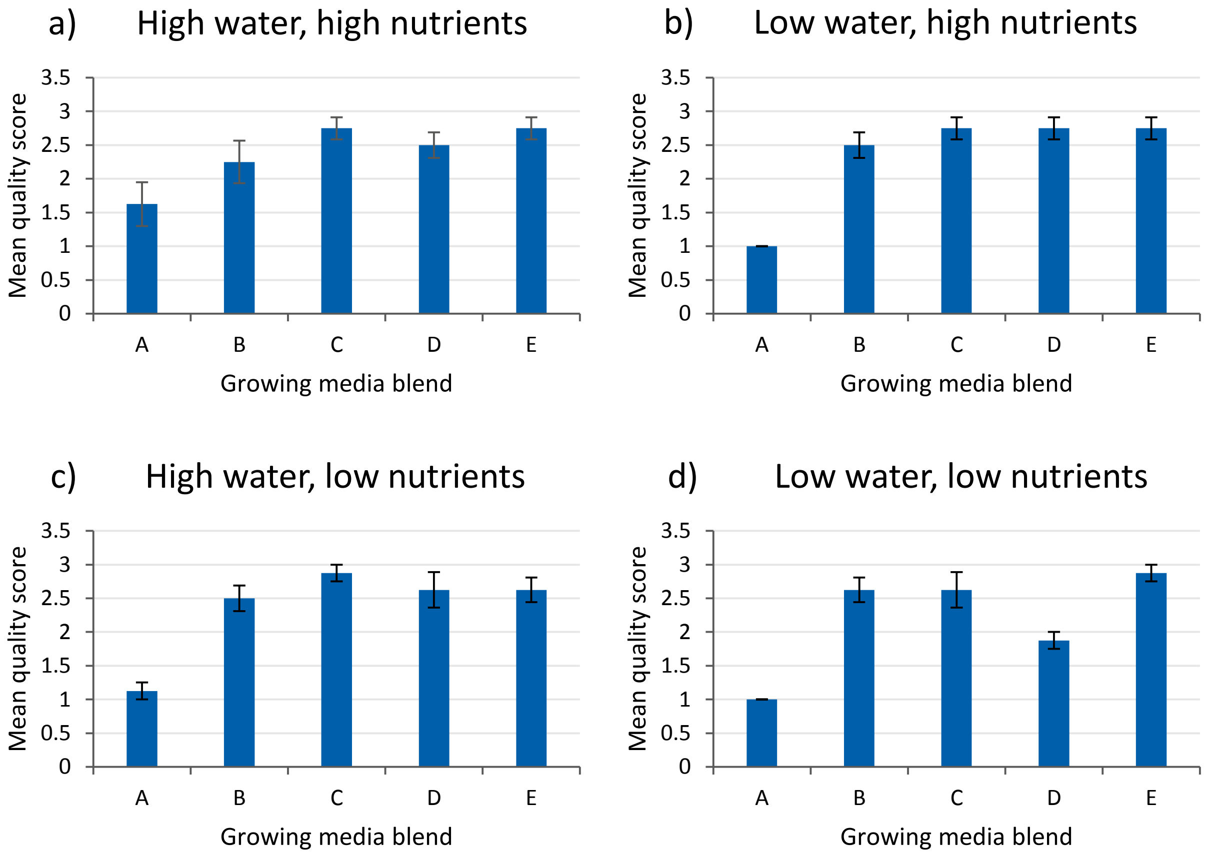


Figure 19. *Viola* mean plant quality score for the five growing media blends at different water and nutrient treatments. Differences across treatments are statistically significant (p < 0.001). Error bars represent 2 standard error, with 19 degrees of freedom (d.f.)

Figure 20. PaMS symptoms observed in some of the treatments, which included leaf bleaching, streaking, stunting and apical blindness.

The height, root quality and number of plants flowering per pack were similar for peat and the blends, indicating that the prototype growing media blends were similar in their plant growing performance for *viola*s.

The *dianthus* were quite similar for all treatments in the growth metrics that were measured. Differences were noted in height and quality in the outlier blend B at the low water and low nutrient treatment (**Figure 21**), suggesting a low nutrient availability and water holding capacity, which was not the case for the other blends.

Figure 21. Highest scoring *dianthus* plants (left) in peat at high water, low nutrient treatment, and (right) lowest scoring *dianthus* plants in outlier blend B at low water, low nutrient treatments.

The peat treatments were quite tall and were generally taller than the other prototype blends (C-E). Although this was not statistically significant, this suggests that the prototype blends produce smaller more compact plants under the growing conditions used in this experiment and may reduce the need for plant growth regulators (PGRs) in commercial production.

All of the three blends closest to the peat in terms of physical properties (blends C-E) performed well in both species, and in the case of the *viola*s outperformed the peat. The outlier blend (blend B) performed worse in the *dianthus* for height and quality and produced symptoms of PaMS in the *viola*s. This suggests that the blends C-E are good performing blends and are suitable for commercial testing on grower holdings in 2017.

Protected edibles – herbs

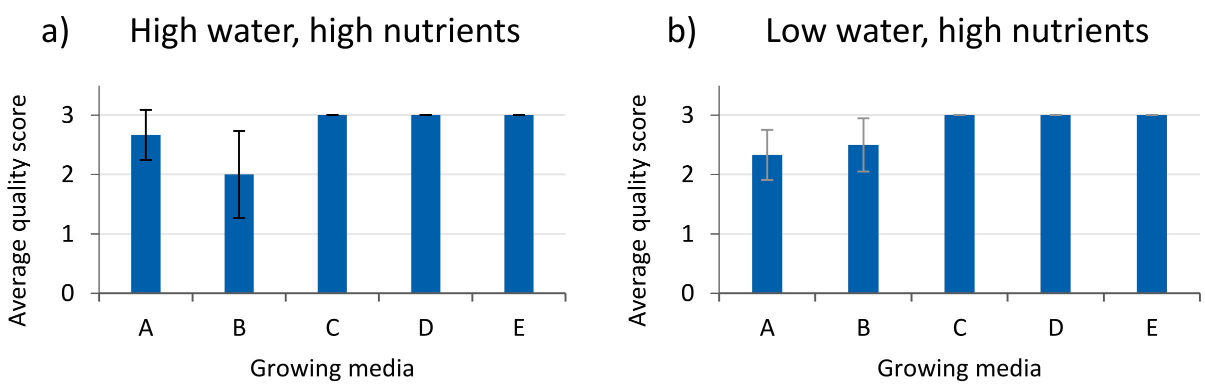
The trial was conducted at ADAS Boxworth, with seeds, pots and sleeves supplied by Lincolnshire Herbs, (Bourne, PE10 0AT) in June 2016. Two separate trials were run for the herbs, one in summer (sown week 29) and one in autumn (sown week 39). Four species of herbs were used over both trials; chive, basil,

coriander and thyme. Three of the four species were used for each trial: the summer trial used chive, coriander and thyme, whilst the autumn trial used chive, coriander and basil.
The full 20 treatments were used in this trial, these comprised of five growing media, two nitrogen levels and two water levels as before (**Appendix 6**).
One bench was used for each trial, with three species on the bench. The bench was split into four sections separated by Perspex, with each containing one ebb and flood tray unit. Once sown the herbs were covered with black plastic and watered overhead by hand until germination had occurred. The plastic was then removed and they were irrigated by ebb and flood using the Priva irrigation system. The plants were watered once per day during the trial for the summer trial and every other day for the autumn trial. The two irrigation treatments were: low - 90 seconds standing in 15 mm water on bench, and high - 180 seconds standing in 20 mm water (**Appendix 8**).

The pots were monitored for germination and the number of germinated seeds counted for each species. Once the plants reached a marketable size all plants were assessed for quality (scale of 1-3), plant height, plant fresh weight and dry weight. For scoring criteria see **Appendix 8**.

In the autumn trial the basil germinated well, but suffered from *Botrytis* and as a result had to be removed from the trial. The remaining herbs grown in the autumn sowing (chive and coriander) were then placed into a shelf life testing facility at 18 °C and 24 hour light to determine plant longevity.

The coriander and chives sown in summer grew well in the growing media blends tested, particularly at the higher nutrient level, this was despite the chive having a lower germination success in one of these blends. There was a significant difference in the average plant quality across treatments in the coriander ($p = 0.003$, d.f. = 19; **Figure 22**) and the chive ($p < 0.001$, d.f. = 19; **Figure 23**). The plants had the poorest quality in the high water, low nutrient treatment, regardless of plant type or growing media blend. Plants grown in the outlier blend B tended to have the poorest performance of the growing media blends tested, especially in the high water, low nutrient treatment.



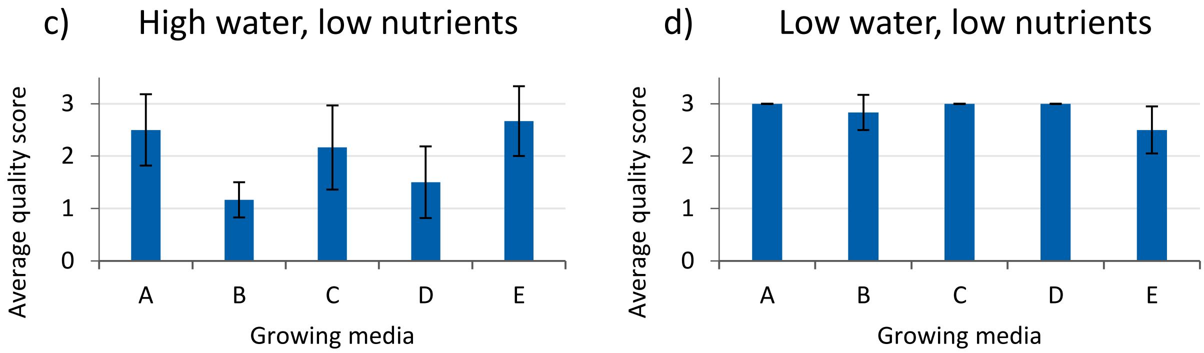


Figure 22. Coriander average plant quality score for the five growing media blends at different water and nutrient treatments. Differences across treatments are statistically significant ($p = 0.003$). Error bars represent 2 standard errors, with 19 degrees of freedom (d.f.)

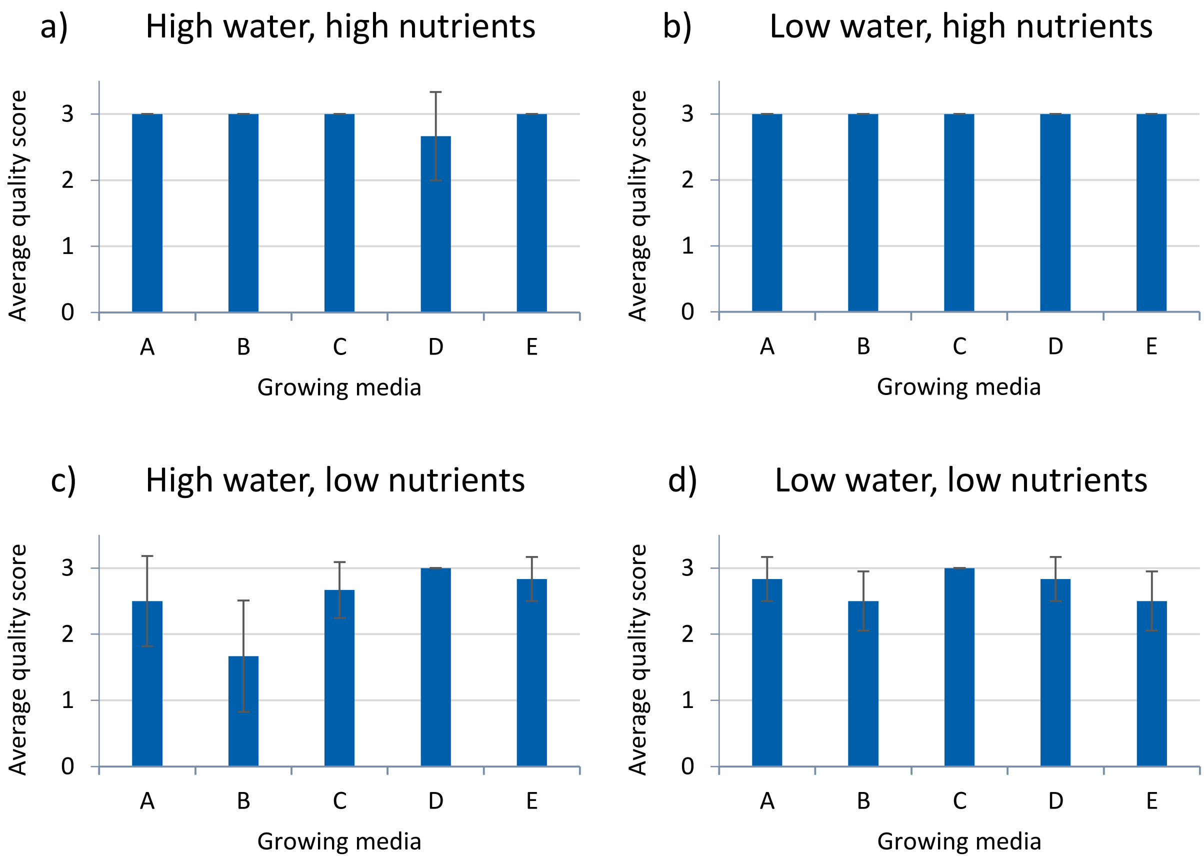


Figure 23. Chive average plant quality score for the five growing media blends at different water and nutrient treatments. Differences across treatments are statistically significant ($p <0.001$). Error bars represent 2 standard errors, with 19 degrees of freedom (d.f.)

The differences in the quality and growth of the thyme were not as marked as in the coriander or chives. This may be due to thyme preferring drier conditions when compared to the other herbs. A similar pattern was seen in the fresh and dry weight of the thyme as in the coriander and chives, with the prototype blends performing as well as the peat and the outlier blend performing the worst overall.

The chive, coriander and thyme generally grew best in the three growing media prototype blends with the high nutrient treatments in the summer sowing. However, the three blends still had comparable plant growth performance to peat at the lower nutrient levels.

In autumn, there were differences in the quality and height in both the chives and coriander, with the plants grown in peat smaller and poorer quality than in the blends. This is likely to be as a result of the irrigation rate being too high for the peat treatment despite the plants being watered every other day. Across all of the blends, the tallest plants were in the low water treatments.

In the shelf life testing, the outlier blend performed worst, with most coriander plants starting to wilt after 13 days in three out of the four treatments. The prototype blends C and E and the peat performed the best, with the plants grown in low water and high N all starting to wilt after 17 days (**Appendix 8**).

The three prototype blends (C-E) generally performed as well as peat in all of the growth performance metrics measured in this trial across all of the herbs tested. The outlier blend B did not perform as well as the other growing media.

Hardy Nursery Stock – Hebes

Young Hebe plants of the cultivars ‘Heartbreaker’, ‘Blue Haze’ and ‘Midnight Sky’ were supplied by Lowaters Nursery, (Southampton SO31 9HH), on 7 July 2016. The trial was split between Stockbridge Technology Centre (STC), North Yorkshire, and ADAS Boxworth, Cambridgeshire, with STC receiving 100 plants of each of the cultivars ‘Heartbreaker’ and ‘Blue Haze’ (200 plants total), and ADAS receiving 100 plants of ‘Midnight Sky’.

The trial at STC was conducted on a sheltered gravel area and was planted on 14 July 2016. The two cultivars (‘Blue Haze’ and ‘Heartbreaker’) used in this trial were split into two blocks for the different feeding treatments, the plants were arranged in five replicate blocks with two plants per plot. There were 10 treatments in the trial, comprising five growing media blends and two target N concentrations. There were two different feeds for the trial with a high target nitrogen (250 ppm N) feed and a low target nitrogen (100 ppm N) feed. The liquid feeds were applied using two Dosatron dilutors in sequence and applied to the surface of the pots using a hand lance. The feeds were applied evenly with every watering.
The HNS trial at ADAS Boxworth was conducted on an ebb and flood bench split into four sections, as for the herbs. The same irrigation rates were used as in the herb trial (

Appendix 9), although the hebes were only watered once every other day.

The hebes were scored for size and colour, as well as monitored for pest and disease throughout the trials. Once the plants reached a marketable size (20 October 2016) all plants in both trials were scored for quality (scale of 1-4) and root coverage (score 0-4) (

Appendix 9).

Some plants from both trials suffered with *Fusarium* wilt, particularly the variegated ‘Heartbreaker’ cultivar. This was across all treatments and was not linked to the growing media used.

The response of the plants to different nitrogen levels varied across the three cultivars. 'Blue Haze' showed no difference in quality between the high and low N treatments, 'Heartbreaker' performed slightly better in the low N treatment and 'Midnight Sky' performed better in the high N treatments (**Figure 24**; $p < 0.001$, d.f. = 19). No notable differences were found in the quality of 'Blue Haze' or 'Heartbreaker' for any of the growing media blends.

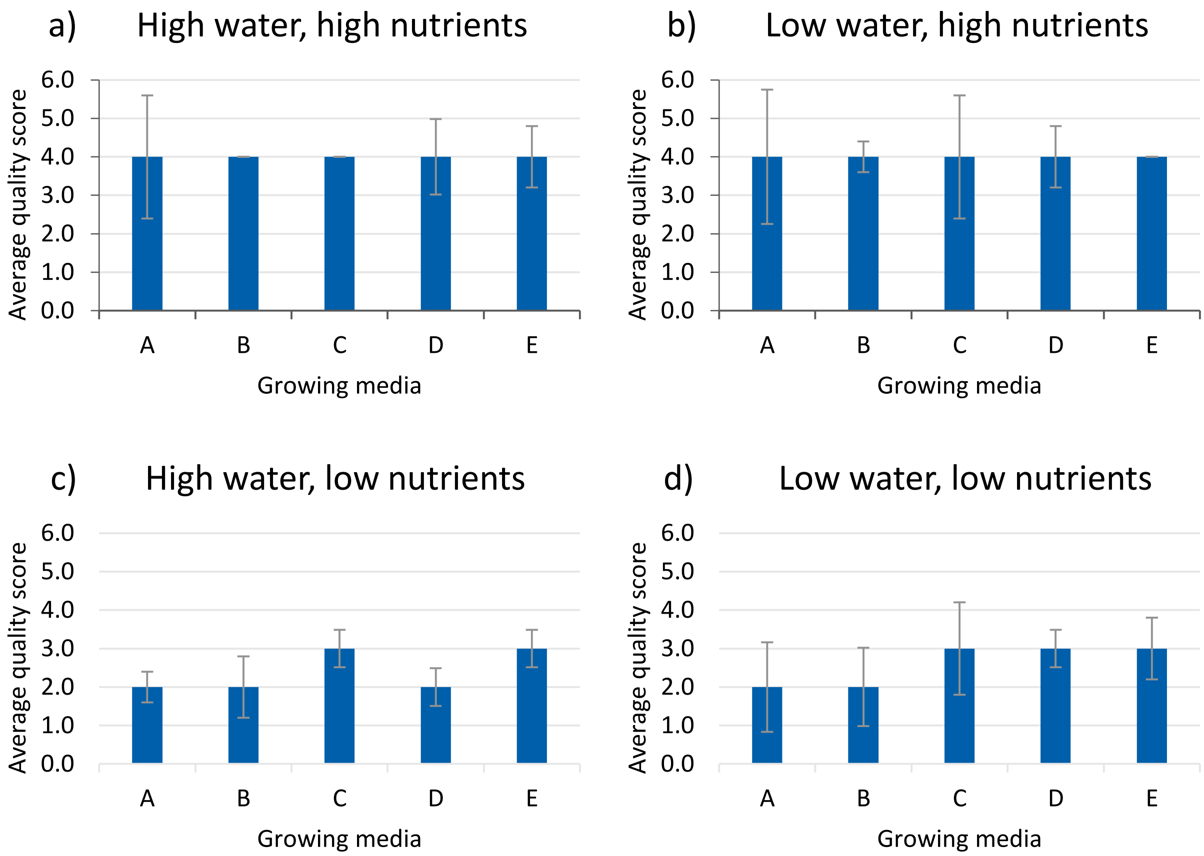


Figure 24. Hebe 'Midnight Sky' average plant quality score for the five growing media blends at different water and nutrient treatments. Differences across treatments are statistically significant ($p < 0.001$). Error bars represent 2 standard errors, with 19 degrees of freedom (d.f.)

In the STC trial there were no differences noted in the performance of any of the blends for the 'Blue Haze' cultivar. However, the outlier blend B was noted as producing slightly smaller plants under low water treatments than the other growing media blends under the controlled conditions of the ADAS trial (**Figure 25**). It could be that the 'Blue Haze' cultivar is more tolerant of a wider range of growing media than 'Midnight Sky' or that the more controlled conditions in the ADAS trial enabled small differences to be magnified and more obvious.

The three prototype blends (C-E) generally performed as well as the peat in the growth performance metrics measured in these trials across all three of the hebe cultivars tested.

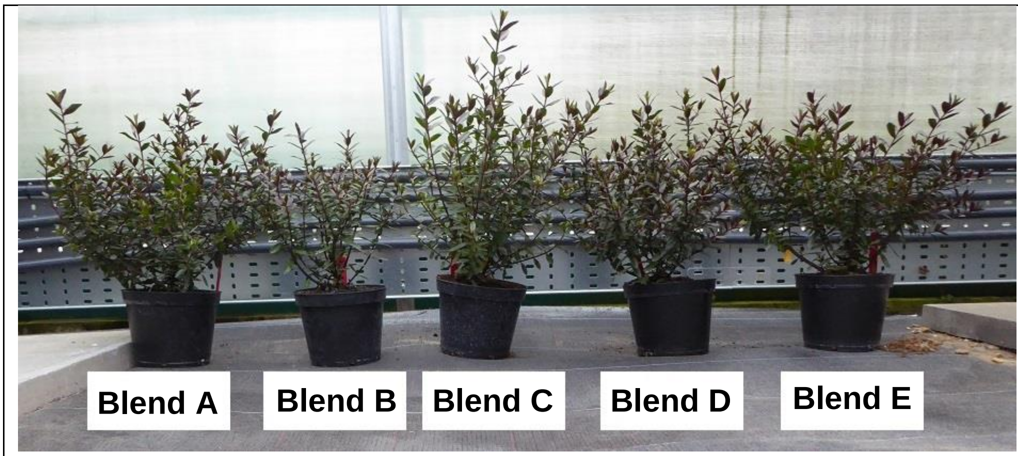


Figure 25. Hebe 'Midnight Sky' plants grown in the five growing media treatments at low water and low nitrogen application (100 ppm N). In this treatment blend B produced smaller, less bushy plants when compared to the other treatments.

Top fruit - Apple and Cherry trees

Maiden apple and cherry trees and pots were supplied by Frank P Matthews (Tenbury Wells, WR15 8TH) in June 2016. Twenty 'Summersun' cherry trees and 50 'Bramley' apple trees were used in this trial and planted into 7L pots filled with the trial growing media blends on 14 June 2016.

Five treatments were used in the cherry trial, these comprised of the five growing media blends, with each of the treatments replicated four times. The cherry trees were irrigated and fed four times per day for a duration of four minutes per irrigation using drippers delivering water at a rate of 2 L per hour. The trees were liquid fed using at a rate of 100 ppm N.

Ten treatments were used in the apple tree trials, comprising the five growing media treatments and two N concentrations (high: 250 ppm N, and low: 100 ppm N). Each of the treatments were replicated five times. The apples were irrigated four times per day for the same duration as the cherry trees.

Detailed assessments were conducted on the apple and cherry trees once per month after planting, with the final assessment on 25 October 2016. The tree metrics measured monthly were: number of branches over 10 cm, top extension (mm), branch extension (mm) and number of leaves per branch. The tree girth (at 10 cm above the graft) was also measured at the beginning and end of the trial.

There was no significant difference in the cherry tree growth across any of the growing media blends used. Bacterial canker was found in some of the trees, however, it was not related to the growing media blends and did not affect the trial.

Overall there were no significant differences in the apple tree growth across any of the growing media blends used at either of the nitrogen levels. The extension of the top leader branch was overall higher in the high N treatment, reaching approximately 800 mm by October (**Figure 26b)**, however this was not significant.

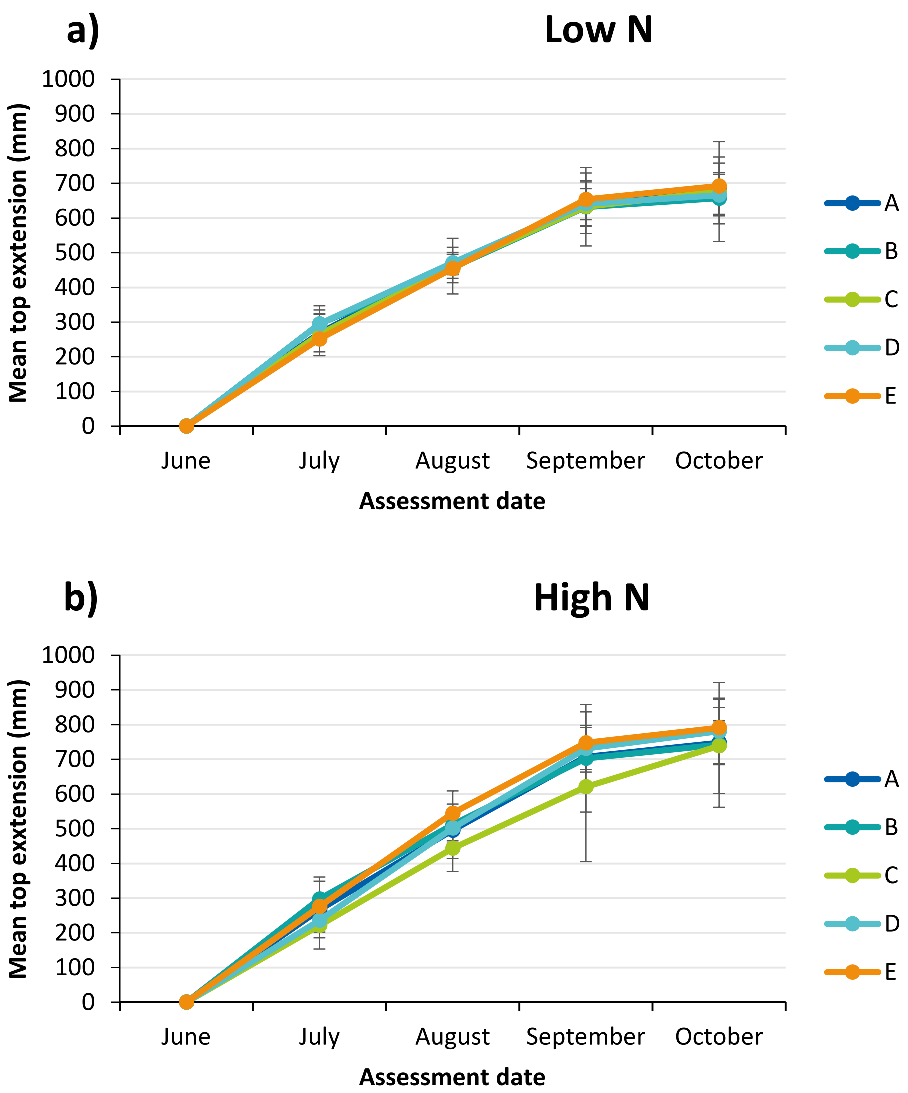


Figure 26. Mean top branch extension (mm) for the five growing media blends at different nutrient treatments: **a)** low and **b)** high nutrient treatments. Differences across treatments are not statistically significant. Error bars represent 2 standard errors, with 19 degrees of freedom (d.f.)

The three prototype blends (C-E) performed as well as peat in the growth performance metrics measured in both the apple and cherry tree trials. No pest or disease was noted in any of the growing media blends during the trial.

Conclusions

Overall, across all of the experimental trials run in 2016, there was a trend for the three prototype blends to produce plants of a similar quality to those produced in the peat control. The outlier blend B, chosen to help validate the model because it had been predicted to perform poorly, tended to produce smaller plants that were of poorer quality compared to the other treatments. Based on the findings from these experimental trials, the three 'best' prototype blends will be suitable for use in the grower trials planned for 2017.

WP4: *Workshop and knowledge exchange events*

Knowledge exchange is an important part of CP138, as key messages from the project need to be communicated to growers and the industry. With **WP1** near completion, and **WP2** and **3** well underway, 2016 was an effective time to begin developing workshops and attending industry events, as this would enable attendees to not only learn about the project and results gathered to-date, but to also view trials in-situ. Knowledge Exchange is not limited to workshops and industry events. It can also take the form of magazine articles (i.e. AHDB Grower, Commercial Greenhouse Grower), technical documents and social media updates (**Tasks 4.1-4.1.2**). **Table 6** outlines the knowledge exchange completed to-date.

Table 6. Knowledge Exchange completed to-date.

Date	KT type	Description
21/01/2015	Conference	BPOA conference – Oxford. Overview of project given by Barry Mulholland.
07/02/2015	Magazine	HDC News article general piece about the project (Claire Shaddick, issue 210, page 5).
03/06/2016	Document	Monograph of methods for analysing growing media and raw materials. Published on ADAS website (http://www.adas.uk/Portals/0/Documents/Technical%20Monograph%20Growing%20Media%20Laboratory%20Methods.pdf).
06/06/2016	Twitter	Twitter account launched - @GrowMediaADAS.
08/06/2016	Magazine	AHDB grower magazine article general piece about the project (Spence Gunn, issue 224, page 5).
16/06/2016	Twitter	Bedding plant trial assessments.
21/06/2016	Event	Bedding and Pot Plant Centre Open Evening – demonstration and discussion of project and bedding trials hosted at Bordon Hill Nurseries and Baginton Nurseries.
28/06/2016	Twitter	Lettuce harvesting.
18/08/2016	Twitter	Apple assessments.
18/08/2016	Twitter	Herb assessments.
25/08/2016	Event	British Herbs Field Day – demonstration stand with herbs. Outlining project and progress, discussing current and future trials.
Sept 2016	Magazine	Commercial Greenhouse Grower article covering the bedding trial at the Bedding and Pot Plant Centre Open Evening in June (September 2016 edition, page 10).
12-13/10/2016	Event	Elsoms Open Days – demonstration stand with lettuce. Outlining project and progress, discussing current and future trials.

25/10/2016	Online magazine	Mini article in Horti Daily advertising the 2016 workshops at Wyevale and Vitacress (http://www.hortidaily.com/article/29740/UK-Developing-new-blends-of-growing-media-for-horticulture).
15/11/2016	Workshop	Wyevale Nurseries workshop (HNS). Overview of project and view of trials. Talks from Susie Holmes and David Talbot and machinery demo from Mechanical Botanical.

In 2016, the project team attended three industry events and hosted one standalone workshop. The industry events were the Bedding and Pot Plant Centre (BPPC) Open Evening (ornamentals), British Herbs Field Day (herbs) and Elsoms Open Day (field veg). At each event, trial plants were demonstrated, along with growing media blends and raw materials, handouts and a project poster. A presentation was also given at the BPPC. All events were very well attended, and overall, approximately 100 growers and industry representatives were spoken to and informed of the project across the three events.

A standalone workshop was held at Wyevale Nurseries, Hereford, on 15 November 2016, and gave attendees the opportunity to view the propagation, liners and finals trials. Plants from the experimental trial at ADAS Boxworth were also brought along for discussion. The event was attended by 24 growers and industry representatives, and the day was well received.

A knowledge exchange portfolio has been developed, which brings together summaries of all events, photographs, comments from event hosts and attendees and articles that have been published externally (i.e. Commercial Greenhouse Grower). For each workshop or industry event, an agreed KE feedback form has been developed, which provides a summary of the event, how the project was demonstrated or presented, the number of attendees and feedback from attendees and hosts. This is a working document which will be added to as the project progresses and will be an important way of encompassing the knowledge exchange component of CP138.

Further events are planned for 2017 (**Table 7**). Generally, nurseries that host a trial will also host a workshop when the trial is at a suitable stage for viewing. However, for some nurseries, they may prefer to link in with an industry event (i.e. G's Field Event) and therefore a standalone workshop may not be the most suitable way to guarantee a high number of attendees.

Table 7. Planned knowledge exchange for 2016 – 2017.

Date	KE type	Description
Feb 2017	Magazine	Article on CP138 submitted to Spence Gunn for AHDB Grower magazine February 2017 issue.
08/02/2017	Event	Herbaceous Perennial Technical Discussion Group meeting. Overview of project to be given by Barry Mulholland.
25/04/2017 **TBC**	Workshop	New Farm Produce workshop (Herbs). Overview of project and view of trials. External speakers TBC.
07/06/2017 **TBC**	Workshop	Vitacress Herbs workshop (Herbs). Overview of project and view of trials. Talks from Susie Holmes and Chloe Whiteside and machinery demo from Mechanical Botanical.
20/06/2017	Event	Bedding and pot plant centre open evening – demonstration and discussion of project and bedding trials hosted at Ivan Ambrose. (Ivan Ambrose may not be willing to host an event but the BPPC will allow us to demonstrate the trial to growers).
22/06/2017	Event	G's Field Event. G's were not willing to host a standalone event in 2016, but are happy to incorporate us into the industry salads field event which they are hosting in 2017. This is outside of the scheduled

		work plan, but they would be happy to host an additional trial so that we would have a crop to demonstrate on the day.

In June 2016, a twitter account for CP138 was set-up, and this has proved to be a very useful way in providing 'snap-shots' of the project (i.e. when a trial has been set up or an assessment completed, photographs can be added to the page for viewers to see). It has also been used to help advertise events and workshops, as well as show pictures of events taking place, which helps to generate interest in the project. As of 30 January 2017, the RSGM twitter account has 68 followers, which are a combination of growers, growing media manufacturers, horticultural companies and independents.

Financial benefits

- At this stage the financial benefits of the work cannot be clearly defined.

Action points

- At this stage of the project there are no action points for growers.

Exploitation

- Publication of a technical monograph: Mulholland BJ, Waldron K, Bragg N, Newman S, Tapp H, Hickinbotham R, Moates G, Smith J, Kavanagh A, Marshall A, Whiteside C, Kingston H (2016) Technical Monograph: Growing Media Laboratory Methods. ISBN 978-1-5262-0393-9, 25 pp. (**WP1**).
- Knowledge transfer events and publications promoting and highlighting excellence in growing media development and use. (**WP4**).

Changes to the project

1. Are the current objectives still appropriate for the remainder of the project? **Yes** X **No** ☐

If **No**, please explain the reasons for any change and the implications for finances and staff time.
(**Any changes must be agreed with the AHDB project manager and the Industry Representative**)

Click here to enter text.

Progress in relation to targets

2. List the agreed milestones for the report period as set out in the contract (or any variation thereof) and when they have been reached. If milestones have not been achieved a full explanation for the reasons why not should be provided.

Milestone		Target Date	Milestone met	
Number	Title		In full	On time
1	**Tasks 1.1-1.1.1.3** Milestone **(M)1** Identified and sourced raw materials and proprietary growing media including peat-free blends and model plant species for sector specific experimental (Boxworth, STC) and on site grower holding trials (year 1, 2016 season).	01/04/2015	Yes	No, two months late. Growing media testing system installation completed – delayed because contract was not signed until late June 2015 and expenditure could not be actioned (until a contract was in place).
2	**Tasks 1.1.2-1.1.4** **M2** Physical properties measured; variation in raw materials quantified	01/10/2015	Yes	No, delay of D1 will cause a concurrent delay to D2. Completed by 30/11/15.
3	**Tasks 1.1.5** **M3** 35-40 blends created	01/11/2015	Yes	No, delay of D1 and D2 will cause a delay in D3. D3 completed on 30/11/15. The numbers of combinations have been worked out (8/9/15) but the precise blend combinations can be worked out once D2 is complete.
4	**Tasks 1.1.6-1.1.6.2** **M4** Modelling of media blending in relation to physical property prediction	01/12/2015	Yes	Delay of D3 pushed milestone completion to 18/12/15.
5	Tasks **1.2-1.2.1** **M5** Commercial media obtained	01/02/2016	Yes	Completed in full and on time
6	Tasks **1.2.2** **M6** Data on commercial media collated and analysed	01/02/2016	Yes	Completed in full and on time

7	Tasks **1.2.3-1.2.3.2** **M7** Initial designs of blends and mixes completed for scoping studies	01/02/2016	Yes	Completed in full and on time
8	Tasks **1.2.4** **M8** Database of raw material and media properties completed	01/02/2016	Yes	Completed in full and on time
9	Tasks **1.3-1.3.2** **M9** Media available for scoping study	01/06/2016	Yes	Completed in full and on time
10	Tasks **1.3.3** **M10** Scoping trials completed	01/10/2016	Yes	Completed in full and on time

Additional supporting material

3. This section should be used to include relevant supporting material such as statistical analyses, tables, graphs, data and additional narrative etc. that are required to demonstrate that the research was conducted and analysed in an appropriate and scientifically defensible manner. If no substantive results are available at this stage the provision of supporting material is not required in an interim report

   This section will not be published on the AHDB website but will be available on request.

Appendix 1
Bordon Hill Bedding

Table 1a. The nine treatments used in both bedding plant trials.

Treatment number	GMM code	Growing media product
1	N/A	Nursery Peat control
2	A	Peat-reduced
3	B	Peat-reduced
4	C	Peat-reduced
5	D	Peat-reduced
6	A	Peat-free
7	B	Peat-free
8	C	Peat-free
9	D	Peat-free

Table 1b. List of scores and definitions used to assess overall transplant quality of the plants.

Score	Definition
1	Obvious quality issues not suitable for transplant
2	Very minor quality issues OK to transplant
3	Perfect no quality issues

Table 1c. List of scores and definitions used to assess plant rooting in the cell.

Score	Definition
0	No root development
1	Rooting in up to 25% of cell
2	Rooting in 26 – 50% of cell
3	Rooting in 51 – 75% of cell
4	Rooting in 76 – 100% of cell

Table 1d. List of scores and definitions used to assess the pullability of the plant in the cell tray.

Score	Definition
1	Plug falling apart
2	Some crumbling of the plug
3	Solid plug, no crumbling

Table 1e. List of scores and definitions used to assess overall plant quality for marketability.

Score	Definition
1	Obvious quality issues not suitable for sale
2	Very minor quality issues OK for sale
3	Perfect no quality issues

	PEAT REDUCED											
	Bench 1						Bench 2					
BLOCK	1	1	1	1	2	2	2	2	3	3	3	3
PLOT	1	1	2	2	5	5	6	6	9	9	10	10
TREATMENT	4	4	3	3	5	5	2	2	4	4	3	3
BLOCK	1	1	1	1	2	2	2	2	3	3	3	3
PLOT	1	1	2	2	5	5	6	6	9	9	10	10
TREATMENT	4	4	3	3	5	5	2	2	4	4	3	3
BLOCK	1	1	1	1	2	2	2	2	3	3	3	3
PLOT	3	3	4	4	7	7	8	8	11	11	12	12
TREATMENT	5	5	2	2	4	4	3	3	5	5	2	2
BLOCK	1	1	1	1	2	2	2	2	3	3	3	3
PLOT	3	3	4	4	7	7	8	8	11	11	12	12
TREATMENT	5	5	2	2	4	4	3	3	5	5	2	2
BLOCK			4	4	4	4	4	4	4	4		
PLOT			13	13	14	14	15	15	16	16		
TREATMENT			5	5	3	3	4	4	2	2		
BLOCK			4	4	4	4	4	4	4	4		
PLOT			13	13	14	14	15	15	16	16		
TREATMENT			5	5	3	3	4	4	2	2		

	PEAT FREE												PEAT			
	Bench 3						Bench 4						Bench 5			
BLOCK	5	5	5	5	6	6	6	6	7	7	7	7	9	9	9	9
PLOT	17	17	18	18	21	21	22	22	25	25	26	26	33	33	34	34
TREATMENT	6	6	9	9	8	8	7	7	8	8	7	7	1	1	1	1
BLOCK	5	5	5	5	6	6	6	6	7	7	7	7	9	9	9	9
PLOT	17	17	18	18	21	21	22	22	25	25	26	26	33	33	34	34
TREATMENT	6	6	9	9	8	8	7	7	8	8	7	7	1	1	1	1
BLOCK	5	5	5	5	6	6	6	6	7	7	7	7	9	9	9	9
PLOT	19	19	20	20	23	23	24	24	27	27	28	28	35	35	36	36
TREATMENT	8	8	7	7	9	9	6	6	6	6	9	9	1	1	1	1
BLOCK	5	5	5	5	6	6	6	6	7	7	7	7	9	9	9	9
PLOT	19	19	20	20	23	23	24	24	27	27	28	28	35	35	36	36
TREATMENT	8	8	7	7	9	9	6	6	6	6	9	9	1	1	1	1
BLOCK			8	8	8	8	8	8	8	8						
PLOT			29	29	30	30	31	31	32	32						
TREATMENT			7	7	6	6	9	9	8	8						
BLOCK			8	8	8	8	8	8	8	8						
PLOT			29	29	30	30	31	31	32	32						
TREATMENT			7	7	6	6	9	9	8	8						

Treatment	Product
1	Nursery Peat
2	A Peat reduced
3	B Peat reduced
4	C Peat reduced
5	D Peat reduced
6	A Peat free
7	B Peat free
8	C Peat free
9	D Peat free

Figure 1a. Trial plan for bedding plants set out on benches at the propagation stage (Bordon Hill).

	Peat	Peat reduced				Peat free			
		Block 1	Block 2	Block 3	Block 4	Block 1	Block 2	Block 3	Block 4
Plot	1	5	9	13	17	21	25	29	33
Treatment	1	2	5	3	4	9	6	7	8
Plot	2	6	10	14	18	22	26	30	34
Treatment	1	3	4	5	2	6	9	8	7
Plot	3	7	11	15	19	23	27	31	35
Treatment	1	5	2	4	3	8	7	9	6
Plot	4	8	12	16	20	24	28	32	36
Treatment	1	4	3	2	5	7	8	6	9

Treatment	Product
1	Nursery Peat
2	A Peat reduced
3	B Peat reduced
4	C Peat reduced
5	D Peat reduced
6	A Peat free
7	B Peat free
8	C Peat free
9	D Peat free

Figure 1b. Trial plan for bedding plants set out on the floor post-transplant (Bagintons Nurseries).

Appendix 2

G's Growers Lettuce

Table 2a. The 10 treatments used in the three lettuce trials.

Treatment number	GMM code	Growing media product
1	N/A	Nursery peat control
2	A	Peat-reduced
3	A	Peat-reduced
4	A	Peat-reduced
5	A	Peat-reduced
6	B	Peat-reduced
7	B	Peat-reduced
8	B	Peat-reduced
9	B	Peat-reduced
10	N/A	Peat-reduced

Table 2b. List of scores and definitions used to assess overall transplant quality of the plants.

Score	Definition
1	Obvious quality issues not suitable for transplant
2	Very minor quality issues OK to transplant
3	Perfect no quality issues

Table 2c. List of scores and definitions used to assess overall plant quality for marketability.

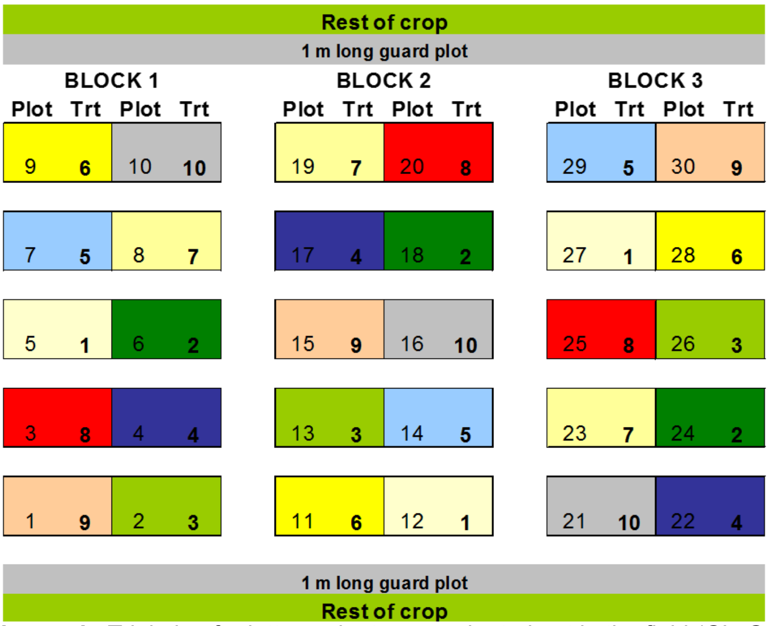
Score	Definition
1	Obvious quality issues not suitable for sale
2	Very minor quality issues OK for sale
3	Perfect no quality issues

60% Peat	P1 T5	P2 T9	P3 T7	P4 T3	P5 T9	P6 T9	P7 T7	P8 T9	P9 T5	P10 T3	P11 T5
	P12 T9	P13 T3	P14 T5	P15 T5	P16 T7	P17 T5	P18 T3	P19 T7	P20 T3	P21 T9	P22 T7
80% Peat	P23 T4	P24 T10	P25 T8	P26 T6	P27 T4	P28 T2	P29 T6	P30 T2	P31 T4	P32 T8	P33 T10
	P34 T6	P35 T8	P36 T6	P37 T10	P38 T4	P39 T2	P40 T4	P41 T6	P42 T10	P43 T2	P44 T8
	P45 T8	P46 T2	P47 T10	P48 T6	P49 T8	P50 T4	P51 T2	P52 T6	P53 T4	P54 T8	P55 T10
Peat	P56 T1	P57 T1	P58 T1	P59 T1	P60 T1	P61 T1	P62 T1	P63 T1	P64 T1	P65 T1	P66 T1

60% Peat	P67 T3	P68 T7	P69 T5	P70 T9	P71 T3	P72 T5	P73 T9	P74 T7	P75 T3	P76 T7	P77 T3
	P78 T5	P79 T9	P80 T7	P81 T3	P82 T9	P83 T7	P84 T3	P85 T5	P86 T5	P87 T9	P88 T7
80% Peat	P89 T2	P90 T4	P91 T6	P92 T10	P93 T8	P94 T6	P95 T10	P96 T8	P97 T2	P98 T4	P99 T2
	P100 T8	P101 T10	P102 T6	P103 T4	P104 T2	P105 T2	P106 T10	P107 T6	P108 T8	P109 T4	P110 T10
Peat	P111 T1	P112 T1	P113 T1	P114 T1	P115 T1	P116 T1	P117 T1	P118 T1	P119 T1	P120 T1	P121 T1

Trt. No.	GMM	Treatment
1	n/a	Peat
2	A	Peat-reduced
3	A	Peat-reduced
4	A	Peat-reduced
5	A	Peat-reduced
6	B	Peat-reduced
7	B	Peat-reduced
8	B	Peat-reduced
9	B	Peat-reduced
10	B	Peat-reduced

Figure 2a. Trial plan for young lettuce plants set out on the glasshouse floor at the propagation stage (G's Growers).



Trt. No.	GMM	Treatment
1	n/a	Peat
2	A	Peat-reduced
3	A	Peat-reduced
4	A	Peat-reduced
5	A	Peat-reduced
6	B	Peat-reduced
7	B	Peat-reduced
8	B	Peat-reduced
9	B	Peat-reduced
10	B	Peat-reduced

Figure 2b. Trial plan for lettuce plants once planted out in the field (G’s Growers).

Appendix 3

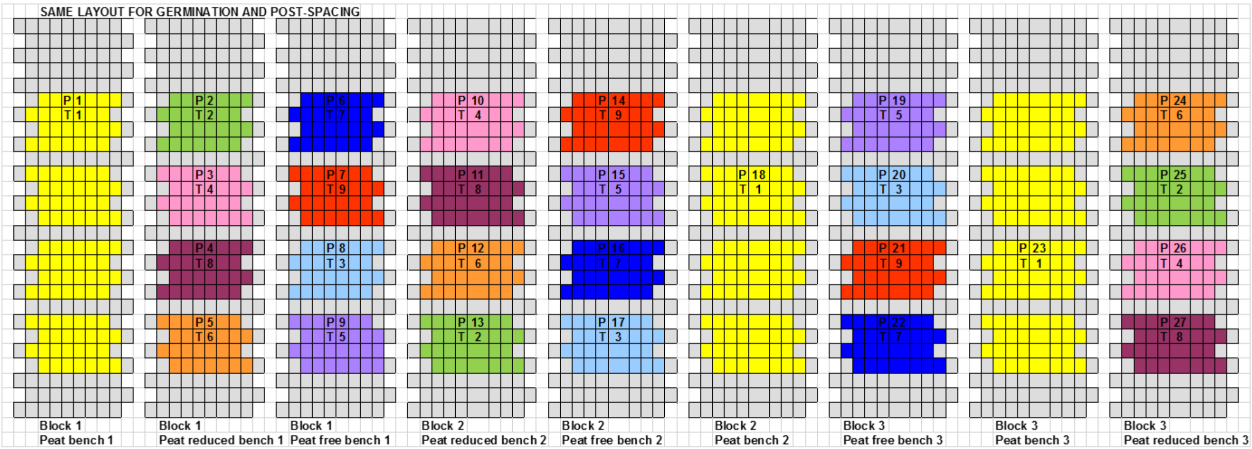
Vitacress Herbs

Table 3a. The nine treatments used in each herb trial.

Treatment number	GMM code	Growing media product
1	N/A	Nursery Peat control
2	A	Peat-reduced
3	A	Peat-free
4	B	Peat-reduced
5	B	Peat-free
6	C	Peat-reduced
7	C	Peat-free
8	D	Peat-reduced
9	D	Peat-free

Table 3b. List of scores and definitions used to assess overall plant quality for marketability.

Score	Definition
1	Obvious quality issues not suitable for dispatch
2	Very minor quality issues OK for dispatch
3	Perfect no quality issues



Trt No.	Treatment
1	Peat standard
2	A Peat Reduced
3	A Peat Free
4	B Peat Reduced
5	B Peat Free
6	C Peat Reduced
7	C Peat Free
8	D Peat Reduced
9	D Peat Free

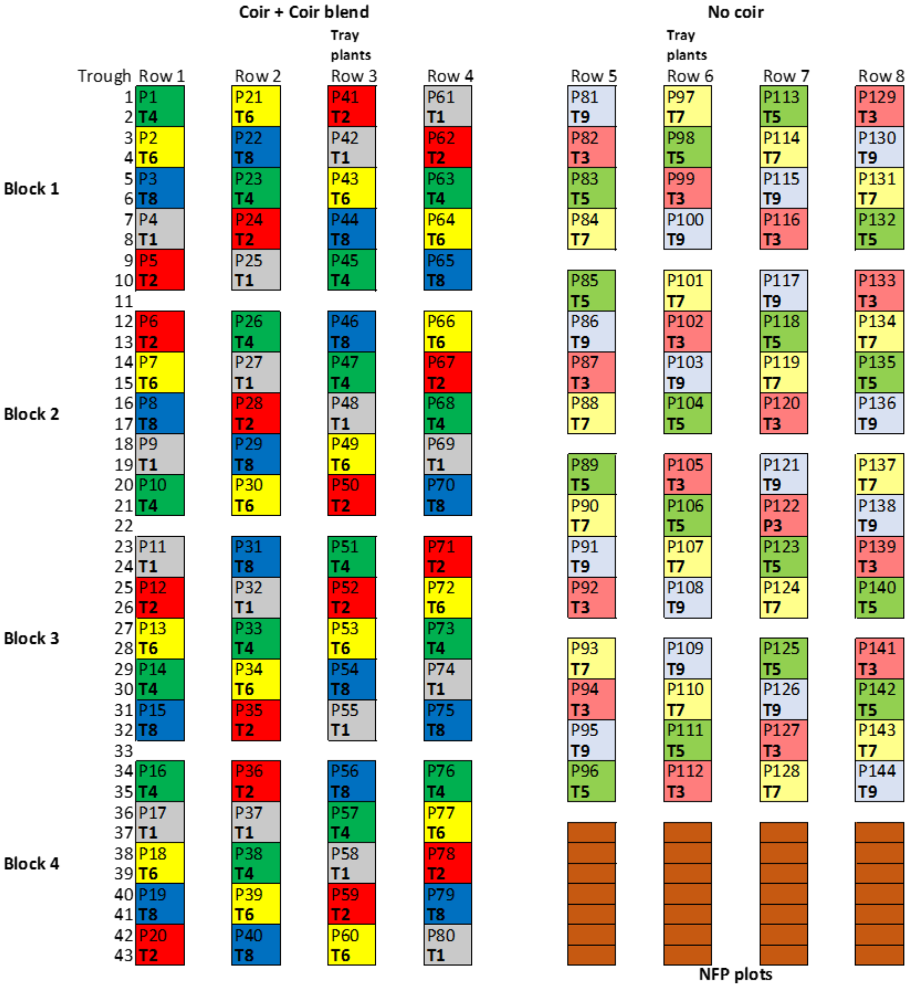
Figure 3a. Trial plan for pot herbs set out on ebb and flood benches (Vitacress).

Appendix 4

New Farm Produce Strawberries

Table 4a. The nine treatments used in the strawberry trial.

Treatment number	GMM code	Growing media product
1	N/A	NFP coir control
2	A	Coir-reduced
3	A	Coir-free
4	B	Coir-reduced
5	B	Coir-free
6	C	Coir-reduced
7	C	Coir-free
8	D	Coir-reduced
9	D	Coir-free



No.	GMM	Treatment
1	N/A	Coir
2	A	Coir reduced
3	A	Coir free
4	B	Coir reduced
5	B	Coir free
6	C	Coir reduced
7	C	Coir free
8	D	Coir reduced
9	D	Coir free

Figure 4a. Trial plan for strawberry plants grown in a designated trials tunnel (New Farm Produce).

Appendix 5

Wyevale Nurseries HNS

Table 5a. The nine treatments used in the propagation trials.

Treatment number	GMM code	Growing media product
1	N/A	100% peat-free
2	A	Peat-reduced
3	A	Peat-free
4	B	Peat-reduced
5	B	Peat-free
6	C	Peat-reduced
7	C	Peat-free
8	D	Peat-reduced
9	D	Peat-free

Table 5b. The nine treatments used in the liner and final hardy nursery stock trials.

Treatment number	GMM code	Growing media product
1	N/A	25% peat-reduced
2	A	Enhanced peat-reduced
3	A	Peat-free
4	B	Enhanced peat-reduced
5	B	Peat-free
6	C	Enhanced peat-reduced
7	C	Peat-free
8	D	Enhanced peat-reduced
9	D	Peat-free

Table 5c. Nutritional requirements for the different HNS species at liner stage.

Species	Liner nutrition
Berberis Darwinii 'Nana'	3.5 kg/m^3 Osmocote 12-14 month
Choisya ternata	3.5 kg/m^3 Osmocote 12-14 month
Euonymus fortunei (Silver Queen)	3.5 kg/m^3 Osmocote 12-14 month
Euonymus japonicus (Green Rocket)	3.5 kg/m^3 Osmocote 12-14 month
Viburnum davidii	3.5 kg/m^3 Osmocote 12-14 month

Table 5d. Nutritional requirements for the different HNS species at finals stage.

Species	Finals nutrition
Berberis Darwinii 'Nana'	2.25 kg/m^3 Osmocote 8-9 month and 3.3 kg/m^3 Osmocote 12-14 month
Choisya ternata	4.5 kg/m^3 Plantacote 12 month
Euonymus fortunei (Silver Queen)	4.5 kg/m^3 Osmocote 8-9 month exact
Euonymus japonicus (Green Rocket)	4.5 kg/m^3 Osmocote 8-9 month exact
Fuchsia (Tom Thumb)	3.5 kg/m^3 Osmocote 5-6 month
Viburnum davidii	2.25 kg/m^3 Osmocote 8-9 month and 3.3 kg/m^3 Osmocote 12-14 month

Table 5e. List of scores and definitions used to assess overall plant quality for marketability.

Score	Definition
0	Dead
1	Nearly dead
2	Unsalable due to poor rooting
3	Unsalable poor quality / disease (specify)
4	Unsalable due to insufficient pot fill / poor leaf colour (specify)
5	Unsalable due to insufficient growth / flower for the time of year / gone over (specify)
6	Not quite saleable but will be in the next 7 -10 days / partially saleable (specify)
7	Good quality saleable
8	Excellent quality
9	Exceptional quality saleable

	Standard	Peat free				Peat reduced			
Plot	1	2	3	4	5	6	7	8	9
Treatment	1	5	3	9	7	6	4	8	2

Plot	10	11	12	13	14	15	16	17	18
Treatment	1	9	3	5	7	8	6	2	4

Plot	19	20	21	22	23	24	25	26	27
Treatment	1	7	5	3	9	2	8	4	6

Trt No	Treatment
1	Wyevale standard
2	A Peat Reduced
3	A Peat Free
4	B Peat Reduced
5	B Peat Free
6	C Peat Reduced
7	C Peat Free
8	D Peat Reduced
9	D Peat Free

Figure 5a. Trial plan for the propagation trial set out in a glasshouse (Wyevale Nurseries).

Choisya ternate	3	9	7	5	8	2	6	4	1
	7	3	5	9	4	8	2	6	1
	9	5	3	7	2	4	6	8	1
	3	7	9	5	8	2	4	6	1
	5	9	7	3	6	4	8	2	1

Euonymus fortunei (Silver Queen)	3	9	7	5	8	2	6	4	1
	7	3	5	9	4	8	2	6	1
	9	5	3	7	2	4	6	8	1
	3	7	9	5	8	2	4	6	1
	5	9	7	3	6	4	8	2	1

Euonymus japonicus (Green Rocket)	3	9	7	5	8	2	6	4	1
	7	3	5	9	4	8	2	6	1
	9	5	3	7	2	4	6	8	1
	3	7	9	5	8	2	4	6	1
	5	9	7	3	6	4	8	2	1

Viburnum Davidii	3	9	7	5	8	2	6	4	1
	7	3	5	9	4	8	2	6	1
	9	5	3	7	2	4	6	8	1
	3	7	9	5	8	2	4	6	1
	5	9	7	3	6	4	8	2	1

Berberis x stenophylla	3	9	7	5	8	2	6	4	1
	7	3	5	9	4	8	2	6	1
	9	5	3	7	2	4	6	8	1
	3	7	9	5	8	2	4	6	1
	5	9	7	3	6	4	8	2	1

Trt No.	Treatment
1	Peat reduced standard
2	A Enhanced Peat Reduced
3	A Peat Free
4	B Enhanced Peat Reduced
5	B Peat Free
6	C Enhanced Peat Reduced
7	C Peat Free
8	D Enhanced Peat Reduced
9	D Peat Free

Figure 5b. Trial plan for the liners trial set out in a glasshouse (Wyevale Nurseries).

INDOOR SPECIES

Choisya ternate

3	9	7	5	8	2	6	4	1
7	3	5	9	4	8	2	6	1
9	5	3	7	2	4	6	8	1
3	7	9	5	8	2	4	6	1
5	9	7	3	6	4	8	2	1

Fuchsia (Tom Thumb)

3	9	7	5	8	2	6	4	1
7	3	5	9	4	8	2	6	1
9	5	3	7	2	4	6	8	1
3	7	9	5	8	2	4	6	1
5	9	7	3	6	4	8	2	1

Euonymus fortunei (Silver Queen)

3	9	7	5	8	2	6	4	1
7	3	5	9	4	8	2	6	1
9	5	3	7	2	4	6	8	1
3	7	9	5	8	2	4	6	1
5	9	7	3	6	4	8	2	1

OUTDOOR SPECIES

Euonymus japonicus (Green Rocket)

3	9	7	5	8	2	6	4	1
7	3	5	9	4	8	2	6	1
9	5	3	7	2	4	6	8	1
3	7	9	5	8	2	4	6	1
5	9	7	3	6	4	8	2	1

Viburnum Davidii

3	9	7	5	8	2	6	4	1
7	3	5	9	4	8	2	6	1
9	5	3	7	2	4	6	8	1
3	7	9	5	8	2	4	6	1
5	9	7	3	6	4	8	2	1

Berberis x stenophylla

3	9	7	5	8	2	6	4	1
7	3	5	9	4	8	2	6	1
9	5	3	7	2	4	6	8	1
3	7	9	5	8	2	4	6	1
5	9	7	3	6	4	8	2	1

Trt No.	Treatment
1	Peat reduced standard
2	A Enhanced Peat Reduced
3	A Peat Free
4	B Enhanced Peat Reduced
5	B Peat Free
6	C Enhanced Peat Reduced
7	C Peat Free
8	D Enhanced Peat Reduced
9	D Peat Free

Figure 5c. Trial plan for the finals trial set out either in a glasshouse or on outside beds (Wyevale Nurseries)

Appendix 6
Experimental trials

Table 6a. Example experimental treatment list for the prototype blend trials.

Treatment no.	Growing media blend	Irrigation treatment	Target N concentration
1	A – Peat control	High	250 ppm N
2	A – Peat control	High	100 ppm N
3	A – Peat control	Low	250 ppm N
4	A – Peat control	Low	100 ppm N
5	B – Outlier blend	High	250 ppm N
6	B – Outlier blend	High	100 ppm N
7	B – Outlier blend	Low	250 ppm N
8	B – Outlier blend	Low	100 ppm N
9	C – Prototype blend 1	High	250 ppm N
10	C - Prototype blend 1	High	100 ppm N
11	C - Prototype blend 1	Low	250 ppm N
12	C – Prototype blend 1	Low	100 ppm N
13	D – Prototype blend 2	High	250 ppm N
14	D – Prototype blend 2	High	100 ppm N
15	D – Prototype blend 2	Low	250 ppm N
16	D – Prototype blend 2	Low	100 ppm N
17	E – Prototype blend 3	High	250 ppm N
18	E – Prototype blend 3	High	100 ppm N
19	E – Prototype blend 3	Low	250 ppm N
20	E – Prototype blend 3	Low	100 ppm N

Table 6b. Levels of nutrients delivered to the trial when fertilizers were diluted to 1:100 (i.e. 1% solution).

		NO_3-N mg/l	NH_4-N mg/l	P_2O5 mg/l	K_2O mg/l	MgO mg/l	Ca mg/l	B mg/l	Cu mg/l	Fe mg/l	Mn mg/l	Mo mg/l	Zn mg/l	EC (mS)
ADAS	**Low N**	95.9	1.3	79.3	200.7	30.5	150.7	0.23	0.09	1.62	0.54	0.05	0.69	1.47
	High N	120.6	129.3	80.0	200.0	30.0	150.7	0.25	0.1	1.75	0.6	0.05	0.75	1.88
STC	**Low N**	90.6	3.9	88.5	220.8	33.6	148.9	0.24	0.09	1.69	0.56	0.05	0.73	1.61
	High N	133.2	119.3	79.0	198.6	31.2	148.9	0.26	0.10	1.82	0.62	0.05	0.78	2.29

Appendix 7
Experimental bedding trial

Table 7a. Irrigation application duration and amounts for each of the irrigation treatments per tray.

Irrigation treatment	Duration of application (s)	Mean application per tray (ml/application)	Application per day (8/07/2016 to 24/07/2016) (ml/day)	Application per day (25/07/2016 to 5/08/2016) (ml/day)	Total applied per tray during trial (ml)
Low water	90	20	40	20	920
High water	180	41	82	41	1886

Table 7b. List of scores and definitions used to assess overall plant quality for marketability

Score	Definition
1	Obvious quality issues not suitable for sale
2	Very minor quality issues OK for sale
3	Perfect no quality issues

Table 7c. List of scores and definitions used to assess plant rooting in the cell.

Score	Definition
0	No root development
1	Rooting in up to 25% of cell
2	Rooting in 26 – 50% of cell
3	Rooting in 51 – 75% of cell
4	Rooting in 76 – 100% of cell

Appendix 8
Experimental herbs trial

Table 8a. Irrigation application duration and amounts for each of the irrigation treatments.

Irrigation treatment	Duration of application (s)	Drain time (s)	Depth of water (mm)	Total time flooded/ application (s)
Low water	90	120	15	210
High water	180	180	20	360

Table 8b. List of scores and definitions used to assess overall plant quality for marketability.

Score	Definition
1	Obvious quality issues not suitable for dispatch
2	Very minor quality issues OK for dispatch
3	Perfect no quality issues

Table 8c. Mean number of days from being placed into shelf life testing that it took for coriander plants to wilt and die. All days have been rounded to nearest whole day.

Treatment	Growing media blend	Irrigation treatment	Target N concentration	Mean number of days until starting to wilt	Mean number of days until dead
1	A	High	250 ppm N	15	18
2	A	Low	250 ppm N	17	19
3	A	High	100 ppm N	17	19
4	A	Low	100 ppm N	16	18
5	B	High	250 ppm N	13	18
6	B	Low	250 ppm N	15	18
7	B	High	100 ppm N	13	17
8	B	Low	100 ppm N	13	18
9	C	High	250 ppm N	16	18
10	C	Low	250 ppm N	17	20
11	C	High	100 ppm N	14	18
12	C	Low	100 ppm N	17	19
13	D	High	250 ppm N	16	18
14	D	Low	250 ppm N	16	19
15	D	High	100 ppm N	16	18
16	D	Low	100 ppm N	15	18
17	E	High	250 ppm N	15	18
18	E	Low	250 ppm N	17	19
19	E	High	100 ppm N	14	18
20	E	Low	100 ppm N	15	18

Appendix 9
Experimental HNS trial

Table 9a. Irrigation application duration and amounts for each of the irrigation treatments.

Irrigation treatment	Duration of application (s)	Drain time (s)	Depth of water (mm)	Total time flooded/ application (s)
Low water	90	120	15	210
High water	180	180	20	360

Table 9b. List of scores and definitions used to assess overall plant quality at the end of both STC and ADAS trials.

Score	Definition
0	Dead
1	Unsaleable (specify reason)
2	Good quality saleable
3	Excellent quality
4	Exceptional quality

Table 9c. List of scores and definitions used to assess plant rooting at the end of both STC and ADAS trials.

Score	Definition
0	No root development
1	Rooting in up to 25% of pot
2	Rooting in 26 – 50% of pot
3	Rooting in 51 – 75% of pot
4	Rooting in 76 – 100% of pot

Declaration

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

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Position	Project Lead and Head of Horticulture

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