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)	ADAS, 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 In these cases, such information should be detailed in a separate annex (unpublished).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 (GMM) 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

- Standard operating procedures have been developed for physical and chemical properties (bulk density, air filled porosity, water retention, pH, electrical conductivity and cation exchange capacity (**WP 1: Task 1.1.1**).
- The procedures developed are new, and will provide a robust platform from which to build predictive models for responsibly sourced growing media blend performance (**WP 1: Task 1.1.5**)., with data which will be derived from experimental testing facilities and on-site grower hosted trials.
- A new testing facility has been built at ADAS Boxworth which will allow pre-commercial testing of selected new blends. Testing existing commercially available growing media has occurred at ADAS and Stockbridge Technology Centre (**WP 1: Task 1.1.4**).

Background and expected deliverables

Research work on growing media amendments and alternative materials to peat have been on-going in the horticultural industry for over 20 years. Initially, a very wide range of potential raw materials were examined, but years of research and grower trials have seen the list refined to four key raw materials: bark, coir, green compost (GC) and wood fibre.

Peat use by the horticultural industry has also changed over this time period, although only a few commercial businesses currently offer plants grown in 100% peat-free substrates, a significant number have now reduced their peat use by 10-50% in their growing media and alternative materials are even used exclusively on a commercial scale in some sectors, such as coir in the soft fruit industry. This is reflected by the official growing media usage figures generated by Defra (*Monitoring the horticultural use of peat and progress towards the UK Biodiversity Action Plan target, July 2010*) which indicated that peat use by professional growers in 1999 was just over 1.1 million cubic metres, this fell to 897,000 cubic metres by 2009, whilst use of alternative materials rose from 62,000 to 276,000 cubic metres in the same ten year period.

Following the Defra *Consultation on reducing the horticultural use of peat in England* in 2010, a Sustainable Growing Media Task Force was created made up of growing media manufacturers (GMMs), growers from a number of sectors, retailers, researchers, and conservation groups. The objective of the group was to examine the various barriers preventing a more rapid uptake of alternative materials by the horticultural industry. One specific area examined by the Task Force was the role of research and development and knowledge transfer in overcoming the technical challenges to facilitate a more rapid move towards using higher rates of peat alternatives.

The overall aim of this project is to assist the industry in a move towards the increased use of responsibly sourced growing media (RSGM). 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 horticultural sectors (**Figure 1**). The project includes all commercial horticultural 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.

Specific project objectives for year one included:

- To gain background information on the production and use of responsibly sourced growing media in the UK horticultural sector.
- To develop standard operating procedures for determining physical and chemical properties for the raw material being tested.
- To test raw materials from four growing media manufacturers (GMMs) and to start to develop a model for creating blends.
- To build and test a new experimental facility to allow pre-commercial testing of new blends.

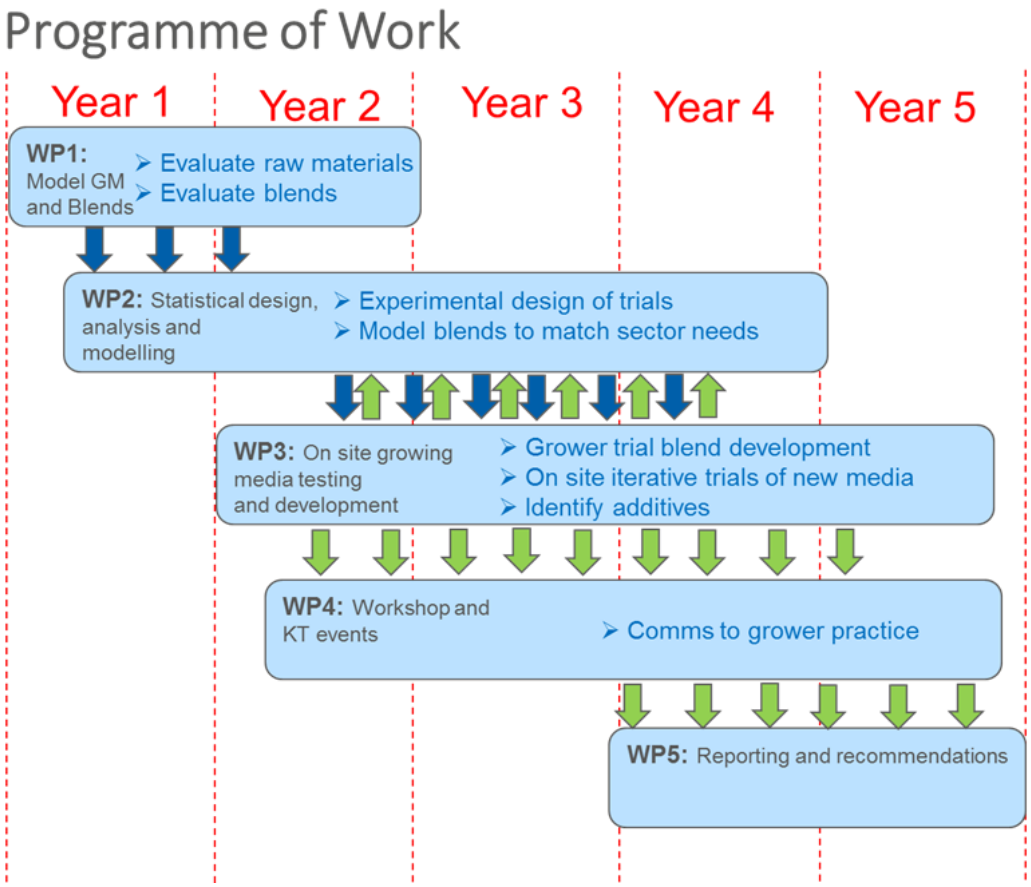

Figure 1. Programme of work across the 5 year project. **Work Package 1** is part way through, **WP2** had been started and will run throughout the project and **WP3** and **4** are due to begin in early 2016. Each WP consists of a number of agreed specific tasks.

Summary of findings

The following section is split into three sections to summarise progress on ***1. Raw material sourcing and testing***, ***2. Industry engagement*** and ***3. RSGM survey of growers and growing media manufacturers***.

1. Raw material sourcing and testing

In year 1 the project has focussed on identifying and evaluating the raw materials supplied by the growing media manufacturers **[WP 1].** Raw material analysis has been completed for modelling RSGM blend development. The statistical and modelling part of the project **[WP2]** began year 1 and will run throughout the project.

Raw material testing and modelling summary **[WP1]**

- **[WP 1]** New testing procedures in accordance with BS and CEN standards for 'soil improvers' (TC223) have been developed for 76 RSGM raw materials (coir, bark, wood fibre and green compost; **Task 1.1.1**) sourced from four leading (>80% of UK market share) growing media manufacturers.
- The raw materials were tested for physical properties, such as, bulk density, air filled porosity in a chamber, water retention (available water at 0.05 and 0.1 bar) on pressure plates and shrinkage (**Plate 1**), and chemical properties, such as pH, EC and CEC (**Task 1.1.3**).

Plate 1. Raw material testing of available water (left) and air filled porosity (right) at ADAS.

- A coding system was developed by STC and ADAS, allowing all RSGM sourced from growing media manufacturers to be coded and anonymised. This coding system will remain in place for the duration of the project.
- Raw material preparation, in particular, soaking times for physical properties characterisation have proved critical in developing a unified standard operating procedure for RSGM.
- The dry bulk density, air filled porosity and available water were used to assess how similar each of the raw materials were to one another in terms of physical properties (**[WP1] Task 1.1.3**).
- **Figure 2** shows each of the samples tested, the closer two samples are to one another, the more similar they are in physical properties.
- The results of this analysis indicate that the samples within each of the raw material types tend to have similar physical properties, although there is some variation between samples in peat and bark.
- Some of the coir and bark samples fall within a similar range as one of the peat samples, suggesting that these materials have similar physical properties to the peat sample and may be useful when creating blends.
- These data have been used to design the blends that will be tested in year two at the on-site testing facility and grower holdings.

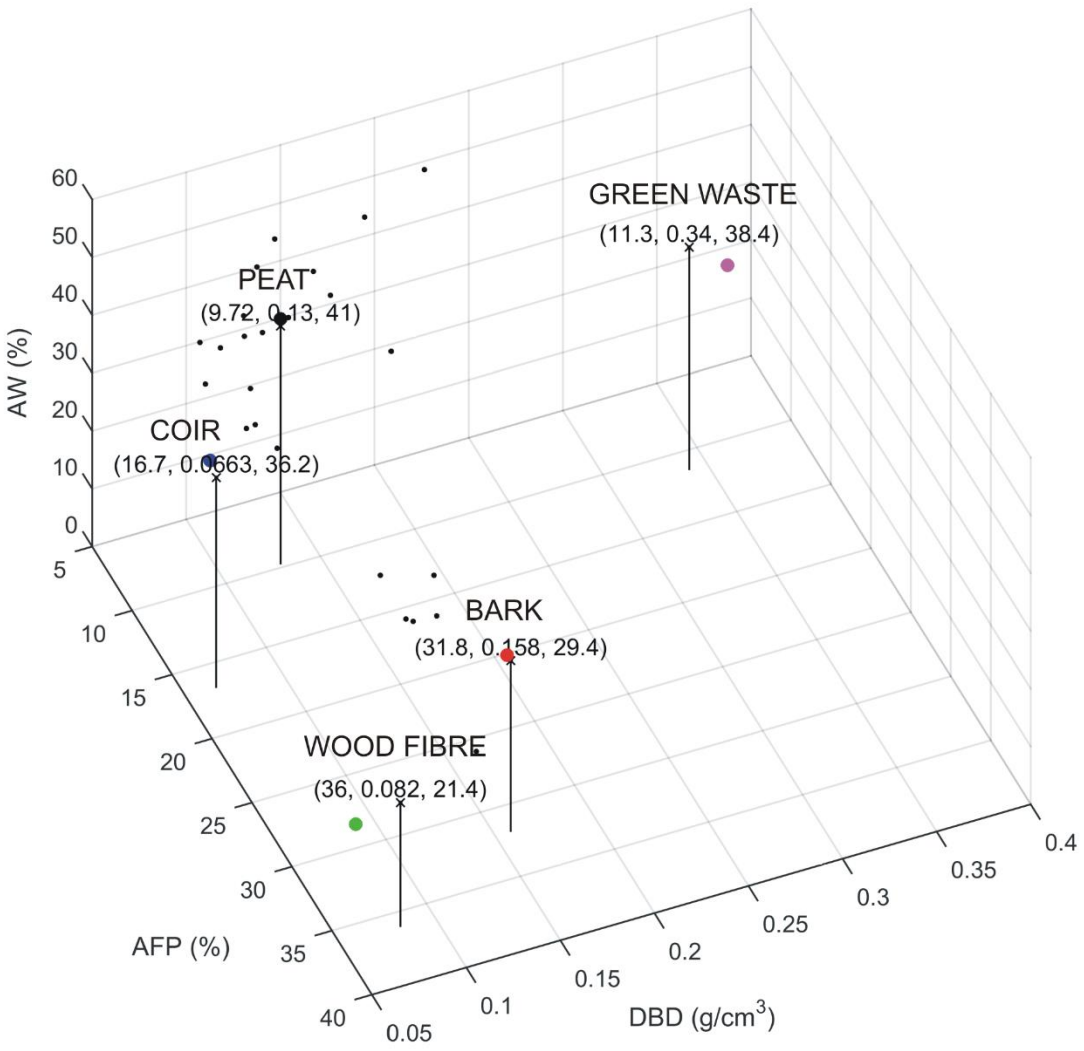

Figure 2. Physical properties (available water - AW, air filled porosity - AFP, dry bulk density - D_b) of raw materials supplied by the growing media manufacturers. Stems mark the position of the average physical properties for peat and the four alternative materials. The position of all of the peat samples are shown as black dots. All samples have been anonymised.

- Physical and chemical data will be used to develop multivariate model approaches to characterising and predicting RSGM blend properties. As integrated growing media and crop growth data is collated and synthesised from on-site and experimental testing facilities, then the model will be further developed to predict plant growth performance for growing media type.

2. Industry engagement

To achieve effective project outcomes there is substantial industry engagement with the industry which can be summarised as follows:

Growing media manufacturers – The Growing Media Manufacturers Operational Group (GMMOG) was formed, which serves the following purposes:

-Meet quarterly
-Supply of raw material for testing
-Blends designed and supplied for on-site trials
-Develop technical SOPs with the research team
-Questionnaire response (100%)

Growers – Each hosted trial is approached on an individual basis, which reflects the bespoke nature of the different growing systems, site practice and product specification. Interaction is required to implement RSGM trials on hosted sites between GMMOG, the grower and project team.

-On-site protocol development
-Host workshops
-Work with project team to gather data
-Questionnaire response (~30%)

Chair for the Advisory and Steering group meetings - Industry, grower led, to agree agenda and discuss progress, works closely with the Project Leader.

3. RSGM survey of growing media manufacturers and growers

Growing media manufacturers and grower survey summary of responses:

- Questionnaires were circulated to the growers and GMMs to gain background information on the production and use of responsibly sourced growing media in the UK horticultural sector at the start of the project (February 2015) (**Tasks 1.1.1.1 - 1.1.1.3**).
- The GMMs and the growers both indicated that the most favoured raw materials used to make peat-free / peat-reduced growing media in the industry were coir, bark, wood fibre and to a lesser extent green compost. This is in line with the raw material selection for CP138.
- All raw materials have potential negatives associated with them on their own, such as cost, supply and composition variability, but many of these issues can be overcome by careful characterisation and mixing of the raw materials.
- The surveyed growers all had some experience of using of responsibly sourced growing media. Most of the growers grew more than 40% of their production using responsibly sourced growing media. Some of the issues encountered by the growers included shelf-life, nutrition and irrigation problems.
- The responses from the GMMs and growers were used to inform what raw materials were going to be tested in this study to formulate blends.
- The potential issues raised by the growers will be addressed by this study in future years to ensure there is confidence in a move towards increased use of responsibly sourced growing media.

Next steps

Testing facilities

- New experimental testing facilities have been installed and have been tested at ADAS Boxworth. Testing facilities will host drip, ebb and flood and overhead sprinkler irrigation systems for 2 L pots and modules. The facility will have the capacity to automatically irrigate at x2 irrigation frequencies and x2 nutrient feeds e.g. standard and high nitrogen.
- The tests included potted herbs (Error! Reference source not found.**2**), vegetables, bedding plants and hardy nursery stock as outlined in **Table 1**. Other testing was performed at partner organisations (**[WP1], Task 1.1.4**).

Table 1. Growing media year 1 experiments. Testing was performed on proprietary blends at several locations in 2015.

Sector	Location	Growing system (testing)	Growing media blends	Bulk Density	Air Filled Porosity (AFP)	Chemical + nutrients	Indicator test species
Field vegetables	STC / Boxworth	Fine sprinklers (modules and blocks) and capillary matting.	Proprietary blends peat alternative plus peat reduced.	Analysis/ multi-variate model (MVM)	Analysis/ MVM	Analysis/ MVM	***Cauliflower:*** (sowing, germination / management issues)

Hardy nursery stock	STC / Boxworth	Ebb and flood and sprinklers (pots), plus drippers and capillary matting	*As above*	*As above*	*As above*	*As above*	***Euonymus and Viburnum***
Mushrooms	Gs	Overhead (trays)	*As above*	*As above*	*As above*	*As above*	
Protected edibles	Boxworth	Ebb and flood (pots)	*As above*	*As above*	*As above*	*As above*	***Parsley and coriander***
Protected ornamentals	Boxworth	Fine sprinkler (module)	*As above*	*As above*	*As above*	*As above*	***Pansy***
Soft fruit	STC	Dripper (bag; S) / Dripper (pot; R)	*As above*	*As above*	*As above*	*As above*	***A grade runners / canes***
Top fruit	Boxworth	Dripper (pot)	*As above*	*As above*	*As above*	*As above*	***Apple 'Gala' / cherry 'Summersun'***

- The data gathered from the experimental testing facilities will inform the plans for on-site grower trials in the next year, as shown in **Figure 3**. In 2016 the commercially available blends trialed at the testing facilities will be used on grower sites in 2017.

Plate 2. Ebb and flood irrigation system, ADAS Boxworth RSGM testing facility, August 2015.

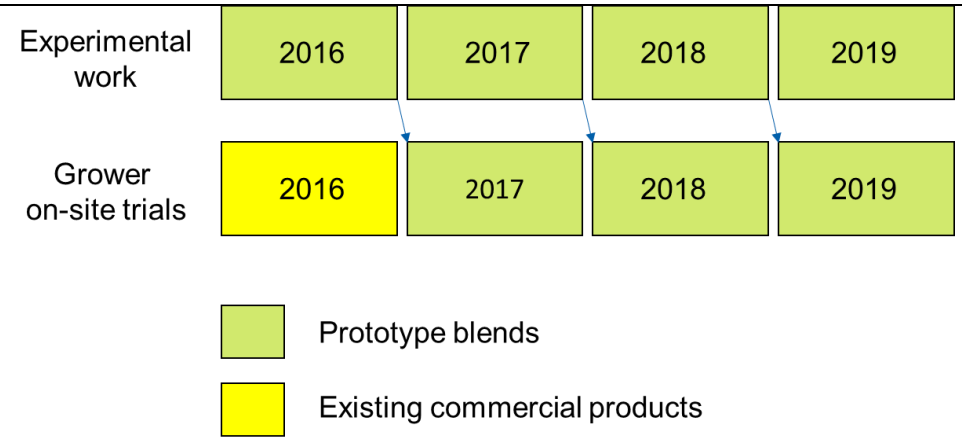

Figure 3. Plan of transition of work from experimental sites to grower holdings in future years. Experimental work performed on prototype blends at testing facilities will inform on-site grower trials in the next year.

On-site grower hosted trials for 2016 have been agreed with robust statistical designs for; hardy nursery stock, pot herbs, bedding plants, strawberry and vegetable transplants. The on-site grower trials and knowledge transfer for 2016 to 2019 are outlined below in **Table 2 ([WP3] Task 3.1**).

Table 2. On-site grower trials and knowledge transfer events planned for 2016 to 2019.

Sector	**Year (Growing season activity)**					
	1 (2015)	**2 (2016)**	**3 (2017)**	**4 (2018)**	**5 (2019)**	**Total**
Mechanisation		MB	MB	MB		3
FV (propagation)		Gs		DP	Gs	3
HNS (propagation)		WP		DNS		2
HNS (production)		WP	L	DNS	JCS	4
M (production)			Gs		Gs	2
PE (production)		VHB	LH		VHB	3
PO (propagation)		BH		R		2
PO (production)		BH	IA	R	DH	4
SF (propagation)			EUP	EUP		2
SF (production)		NFP	NFP		NFP	3
TF (propagation)			FM	FM		2
Total on site trial / KT event No.		8	8	8	6	*30*

MB – Mechanical Botanical, Gs – Gs, DP – Delfland Nurseries, WP – Wyevale Plants, DNS – Darby Nursery Stock, L – Lowaters, JCS – James Coles and Sons, VHB – Vitacress, LH – Lincolnshire Herbs, BH – Bordon Hill Nurseries, R – Roundstone Nurseries, IA – Ivan Ambrose, DH – Double H Nurseries, EUP – EU Plants, NFP – New Farm Produce, FM – Frank P Matthews

RSGM prototype blend development

- Responsibility criteria scores, which have been identified as part of the Defra P4 project, have been requested for the raw materials sourced, but elements of the P4 methodology as far as we know require 'fine tuning'. Once the data becomes available then we can ascribe responsibility criteria scores to the outputs of the current project. This forms part of **Task 1.1 [WP1]**.
- The first prototype blends have been identified to develop the multi-variate model approach for RSGM blend development (**WP1: Task 1.1.5**). These were formulated in late 2015 and tested in 2016 at ADAS Boxworth and STC, prior to use on commercial holdings.

- **Figure 4** shows how the four raw materials (coir, wood fibre, bark and green waste) will be mixed to create new blends. This part of the study will use a 19 point design comprising: 4 one-component, 6 two-component, 4 three-component and 5 four-component mixtures. Blends will be created to obtain mixes with physical properties as close to peat as possible and raw materials from different GMMs will be mixed together.

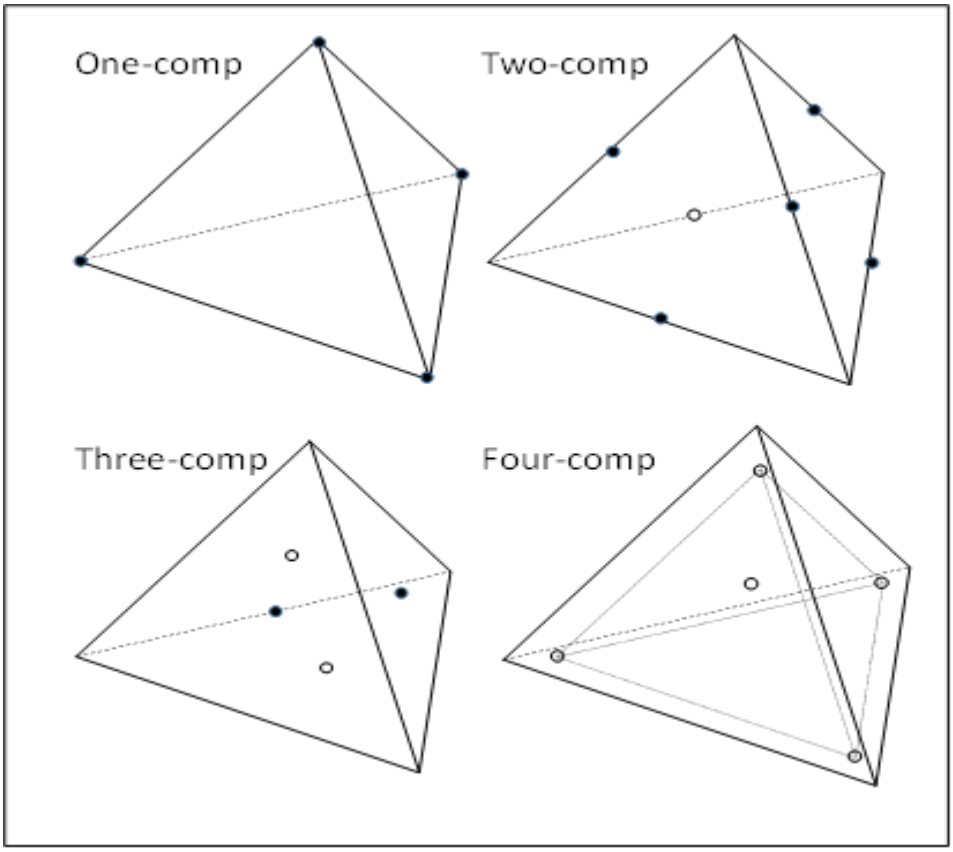

Figure 4. The experiment to investigate the physical properties of the mixtures of coir, wood fibre, bark and green waste (**WP1, Task 1.1.5**) has been designed. The study will use a 19 point axial augmented simplex centroid design comprising: 4 one-component, 6 two-component, 4 three-component and 5 four-component mixtures.

Knowledge transfer

Knowledge transfer activities which will be integrated with on-site RSGM grower trials (**Table 2**) are being planned and developed for 2016 and beyond, and the type of information that will be sought is summarised in **Table 3**.

Table 3. Growing media KT events for years 2, 3, 4 and 5 experiments at grower sites to communicate the results of growth performance, modelling work and application to growing media development, mechanisation issues and post-harvest evaluation.

Targeted feedback sought from growers	Use of data
Score trials independently (scoring system to be determined by ADAS and IFR statisticians).	Compare scores against experimental data and MVM modelling.
Issues for selected blends for individual business (score for handling, on site samples and ties in with mechanisation – methodology to be determined).	Compare scores against known handling issues established in mechanisation workshops.
Post-harvest performance evaluation. Seek individual scores of post-harvest performance (methodology to be determined).	Compare scores against model outputs and scientific trial data.
Management difficulty perception from grower audience, individual scores sought – for irrigation management and potential nutrient issues. Again compare scores against scientific data.	Compare scores against model outputs and scientific trial data.
Cross sector applications identified and asked for from grower audience.	Breadth of knowledge sought from growers to realise new applications in other production sectors e.g. recycling, disease problems outside

	each targeted workshop. Information exchange and awareness.
Costs and growing media performance. Score likelihood of success against price concerns. How confident are growers of managing a difficult (irrigation / nutrition) but cheaper growing media?	Assess the level of risk growers are willing to take against price of growing media and final plant product. How does the industry mitigate against growing media sourced problems?

Financial benefits

- The financial benefits to the growing media manufacturers, growers and the retailers will be understood and reported as the project progresses.
- The industry has enthusiastically engaged with the work as there is value in having a wider choice of substrates available for each production sector.
- The project integrates a series on industry and experimental trials; the industry has welcomed the move away from self-funded stand-alone trials, to a combined effort for RSGM.
- The work will develop an improved technical dialogue between researchers, funders, growers and growing media manufacturers for RSGM.
- The project will provide a robust evidence base for policy and commercial interests, which will identify selected raw materials to constitute RSGM use in UK commercial horticulture production.

Action points

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

Exploitation

Publication of the SOPS for selected physical and chemical attributes of coir, wood fibre, bark and green compost is in preparation. This is an important output from the first part of **WP1**.

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**)

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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.
		Click here to enter a date.		

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.

Questionnaires were circulated to the growers and growing media manufacturers to gain background information on the production and use of peat-free growing media in the UK horticultural sector close to the start of the project (Feb 2015).

Key points from growing media manufacturer and grower survey responses

All growing media manufacturers (GMMs) questioned in this survey had experience of using peat-free and/or peat-reduced growing media and currently sell peat-free and/or peat-reduced growing media. Responses were received from five growers representing propagation, hardy nursery stock, protected ornamentals and protected edibles with all growers having had experience of using peat-free and/or peat-reduced growing media. All peat-free / peat-reduced growing media was bought in as ready-prepared mixes.

The responses from both groups have been assembled into related topics, including reason and extent of use, cost and performance.

Usage

Production favoured peat-reduced growing media which typically represented between 20 and 30% of overall production by volume. Peat-free growing media was usually limited to less than 10% of overall production by volume.

Most of the growers responding to this survey grew more than 40% of their production using peat-free and/or peat-reduced growing media indicating significant progress in this area. A wide range of plants were gown using peat-free and/or peat-reduced growing media across different horticulture sectors (**Table i**).

Table i.. Plant produced using peat-free and/or peat-reduced growing media across sectors.

Propagation	Wide selection of plants in modules e.g. artichoke, beans, beetroot, brassicas, celeriac, celery, chard, courgettes, fennel, herbs, leaf beet, leeks, lettuces, onions, oriental vegetables, pea, rhubarb, rocket, squashes, strawberries, sweetcorn, winter salads, flowers
Hardy Nursery Stock	Berberis, Chaenomeles, Choisya, Escallonia, Forsythia, Potentilla, shrubs and herbaceous plants, fruit and ornamental trees
Herbaceous Perennials	Leucanthemum, Lupin, Peony, Pulmonaria, Veronica and Salvia.
Protected Ornamentals	Argyranthemum, Cyclamen, Dahlia, Dianthus, Gypsophila, Nemesia, Primrose and Rosemary
Protected Edibles	Numerous herbs

It is not possible to say the percentage of peat substitution achieved although one grower stated that the majority of their crops are grown with ~30% peat alternatives in the mix and that peat-free was only used in their plant trials. One grower had a noticeably lower use of peat-free and/or peat-reduced growing media (0 to 10%) and it is possible that this is a sector-specific issue.

Reasons for use

The reasons for interest in peat-free and/or peat-reduced growing media were numerous and varied and can be grouped under four headings: customer-focused, political, sustainability and technical. These are presented in Error! Reference source not found.**ii** below.

Error! Reference source not found.**ii.** Reasons for interest in peat-free and/or peat-reduced growing media.

Customer-focused	Customer demand, potential customer perception and pro-actively supporting customers to meet their environmental policies.
Political	Government targets; political and NGO pressure e.g. Soil Association; Environmental policies are needed for government tendering.
Sustainability	Resource use management; responsible sourcing policy; to ensure company survival if peat usage rules change in the future.
Technical	To keep abreast of new techniques and potential improvements in growing media.

Components

Responses were received from four growers about the optimum peat-free / peat-reduced mix, although only two of the growers indicated a preference. One indicated a limit of 30% peat reduced due to problems with wetting and increased water usage whilst the second indicated that the mix must contain at least 50% peat to match existing product quality. The third grower did not specify a preferred mix although stated that the important characteristics were consistency, reliability and price. The final respondent currently used mixes based on wood fibre but thought that a blend of materials would produce a better growing media, including wood fibre, coir, rice husks and bark.

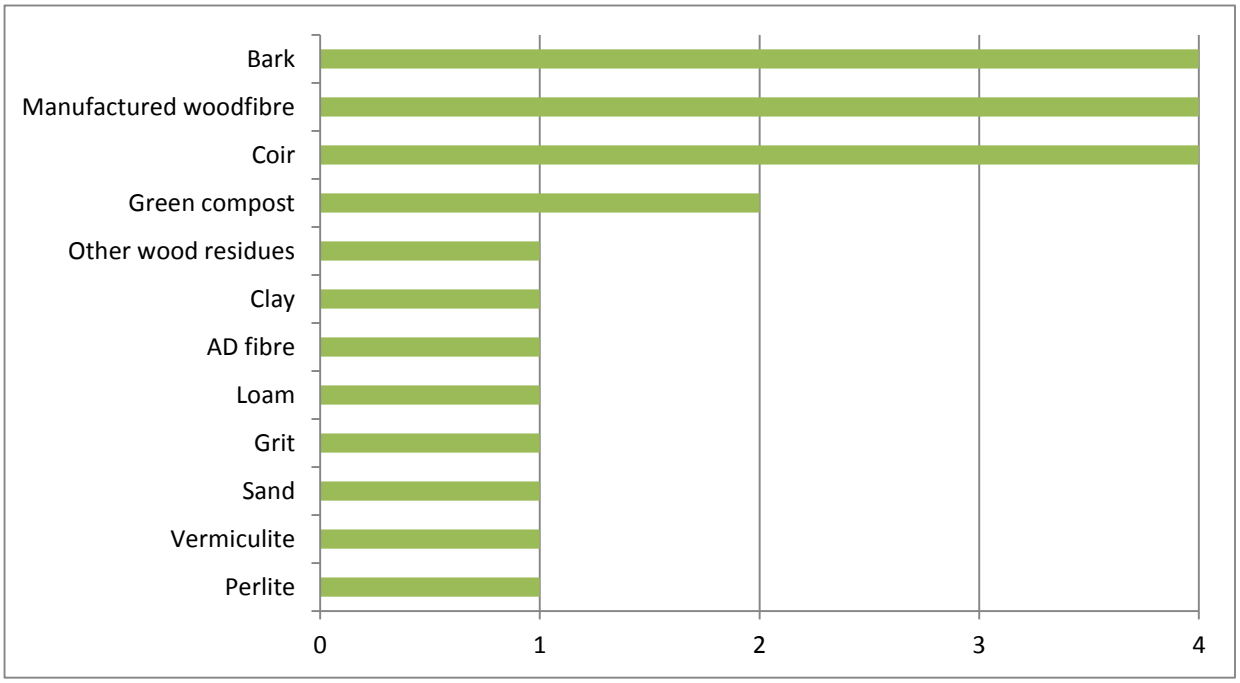


Figure i. Components used in peat-free / peat-reduced growing media used by growing media manufacturers.

The favoured components of peat-free / peat-reduced growing media for both the GMMs and the growers were bark, manufactured wood fibre and coir which were used by all GMMs interviewed. Green compost was used by half of the GMMs and 60% of growers. Other components used by the surveyed GMMs and growers are shown in Error! Reference source not found.**ii*Figure*** .

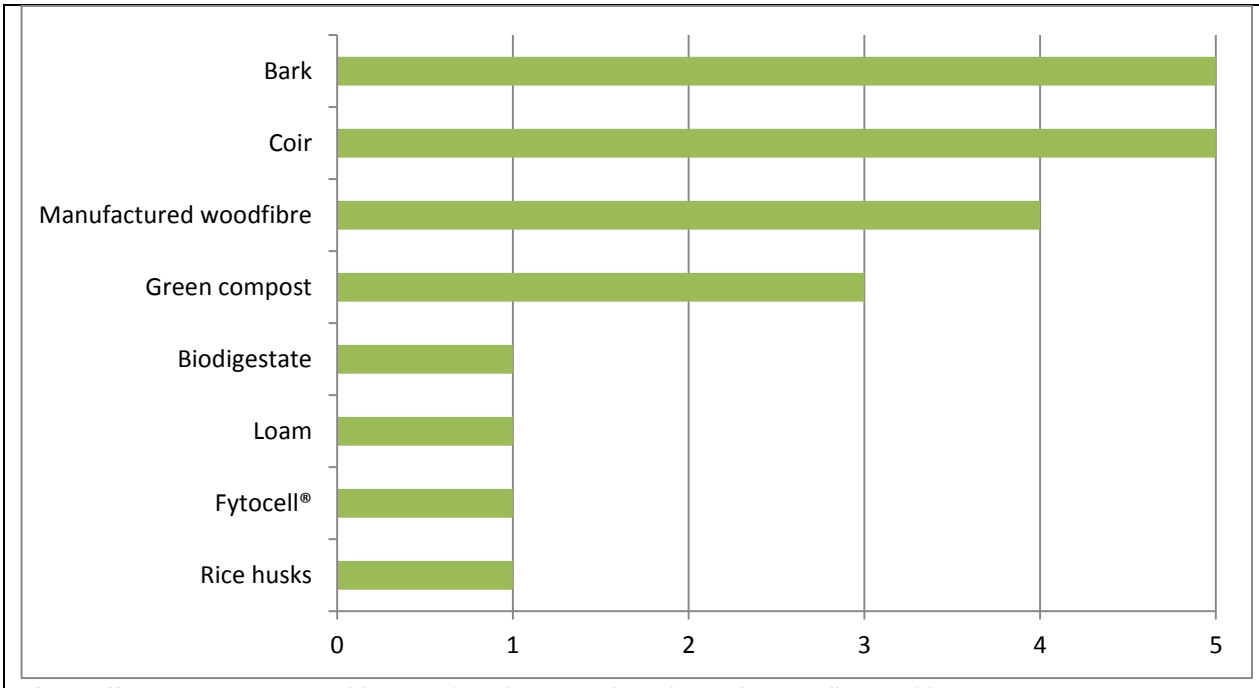


Figure ii. Components used in peat-free / peat-reduced growing media used by growers.

Coir can be used on its own for certain sectors, as it has some similar properties to peat and it has the advantage that it can be regenerated, but has to be treated to do so. Pine bark was considered to be an important component of a quality substrate and was available locally although its availability may be limited due to it being consumed for energy production. Wood fibre is becoming more popular as a material for growing media, but its price depends on the price of wood chips, which competes with fuel and chip board demand. Peat was stated to still be the most consistent, flexible, widely available low priced raw material.

The GMMs generally considered that no one material provided the answer and that blends of materials are the best options going forwards to utilize the properties of mixes and avoid over reliance on any one material. Good results had been achieved with coir, wood fibre and bark combinations although green compost may be used in retail products.

The responses from the GMMs and growers have been used to inform what raw materials will be tested in this study to formulate blends.

Consistency/reliability of sourcing

Half of the GMMs indicated that the raw materials could be easily and reliably sourced most of the time, although price and competing users (e.g. biomass users) were potential issues. Bark and good quality green compost were stated to be limited in supply. Wood fibre and bark supply was variable, as the GMMs were in competition with biomass requirements e.g. co-firing with peat in power stations in Sweden. This can lead to a lack of long term stability in the supply chain since the demand of the GMM is not large when compared to other competing users. Coir was available from Sri Lanka and India, but haulage was considered to lead to environmental questions. The growers and GMMs both expressed concerns over availability of good quality coir in some years, as its availability and outturns can be affected by rainfall and monsoons.

Cost

Cost was a major issue for both the GMMs and the growers. For the GMMs the favoured raw materials identified previously were up to 2 to 5 times the cost of local peat although, in some instances, this can be competitive with imported peat. The best quality pine bark was up to 3 to 5 times more expensive than peat, with wood fibre less expensive at only 2 to 3 times the cost of peat with further cost savings obtained through in-house production. Coir was considered to be 4 times as expensive as peat.

The cost of peat-free / peat-reduced growing media to growers showed much variation, which would be expected since this depends on the type of mix within the peat-free media and the quantity of peat in a peat-reduced growing media. One grower indicated that peat-reduced blends were cheaper than peat although all growers using standard mixes indicated that peat-free blends were 21 – 44% more expensive than standard peat-based mixes. Cheaper mixes were seen to be of inferior quality by one grower. For blocking compost, peat-reduced is 104% of

the cost of peat-only blocking compost. Peat-free module compost is 300% of the peat-reduced price (at current exchange rates).

Most of the grower respondents had no additional costs apart from the increased cost of the growing media and increased monitoring whilst becoming familiar with the product. Indeed, one grower found that they achieved more pots per cubic metre, presumably as a result of a reduced product bulk density, increased potting speed due to enhanced flow characteristics and better disease control which may lead to reduced chemical input. However, two of the growers expected to or had experienced using supplementary feed to buffer nitrogen lock-up. Irrigation costs were thought to be higher if equipment changes or increased monitoring were required, although the input of plant growth regulators may be reduced due to more compact growth in peat-reduced media. Transport costs may also change depending on the weight of the final product. A further grower had experienced crop failures due to peat-reduced grown plants being more susceptible to disease and stated that peat-free media were only used in their trials due to the inadequate shelf-life of the final product.

Performance

Responses relating to different areas of performance have been separated below, with a table of negative experiences from the growers at the bottom of this section (**Table 5**). The GMMs communicated concerns that growers had a negative perception of the performance of peat-free and peat-reduced growing media and there was often no attention to re-setting machinery to handle new materials, so the mixes are seen to fail before any plants are grown.

The GMMs indicated that information can be provided to guide the grower in the management of the crop when using a new substrate, from the point of view of watering and nutrition. One of the problems is that there are no standard parameters that can be applied, and the experience gained using peat mixes over many years is not directly applicable to other mixes. All of these issues will be monitored and addressed as part of this project and recommendations communicated to growers at knowledge transfer events.

Nutrition

Most of the growers responding to the survey used either controlled release fertilisers or liquid feeding when using peat-free and/or peat-reduced growing media. One grower used fertilisers incorporated in the substrate to get through germination and the early development period and then supplied feed via flood and drain irrigation – this was the same for all media used by this particular grower.

Four of the growers had experienced issues with nutrition when using peat-free / peat-reduced growing media. Potential causes of this were identified and included, unevenly mixed media, nitrogen lock-up in bark and low cation exchange capacity. Overall, many of these issues were able to be overcome by liquid and foliar feeding. Cationic exchange capacity is particularly important for nutrition of flood and drain irrigation systems and many ingredients do not hold onto nutrients making feeding more challenging and shelf-life difficult – this problem has been reduced by one grower by maintaining a minimum 50% peat fraction.

Irrigation

The most common type of delivery system for irrigation was overhead. Two of the growers used drippers and a further grower used capillary matting with additional hand watering. One grower used flood and drain irrigation for all production with pot moisture levels assessed by hand. Two of the growers had experienced issues with irrigation. One of the main problems with irrigation is the fact that the media remains dry at the top (which is generally a positive), however it means that the 'grower' always needs to knock the pot out to determine the moisture content of the pot before deciding how much irrigation to apply. Coir and bark both need more irrigation than conventional peat-based mixes. Electrical conductivity is only likely to be a problem in poor quality coir or if incorporating too high a level of a composted/digested type of material.

Pests and diseases

Three of the growers responding to the survey had found no increased need for pest and disease control measures for peat alternatives compared with peat. Indeed, one suspected that disease control was improved when using peat alternatives. However, one grower noted that the use of organic fertilisers attracted and increased the number of sciarid flies and a second grower noted increased disease on peat-reduced mixes (downy mildew on basil and powdery mildew on parsley) requiring increased chemical inputs to control.

Slumping

Slumping and shrinkage has been found by GMMs to occur with some peat alternatives, for example, wood fibre is not as physically stable as moderately decomposed peat, and hence slumping in the pot occurs. However, these problems can largely be overcome by correct mix design and formulation through the introduction of other materials which counteract the problems. Where it is used as a percentage of the mix, it is considered not to present a major issue and similar issues have been known to occur in young peats. Only one grower reported problems with slumping/shrinkage and suggested that it was not possible to overcome this if it was extreme (more than 5% of the pot height).

Table iii. Negative experiences of growers using peat-free and/or peat-reduced growing media

Structure, handling and shelf-life	Consistency can be an issue. Poor mixing giving uneven plugs in tray. Peat-reduced media with wood fibre is difficult to compress into the pot as it is so 'open'. This does give some instability initially after potting. Shelf-life is generally poorer. Substrate heating has occurred when delivered in bulk loads. Slumping of the growing media in the pot has also been a problem on some trials.
Technical	Water and nutritional requirements are quite different and need learning. Some plugs have little pH control giving yellow plants. Lock-up of fertiliser and poor growth.
Availability	Quality coir was in short supply during 2014.
Plant performance and disease	Peat-reduced-grown basil was more susceptible to downy mildew and all varieties take longer to grow. Quality is compromised during hot, very bright weather. A significantly higher microbiological risk. Quality issues with Argyranthemum plants grown on capillary matting on four separate trials. Delayed growth of several crops in peat-free mixes.

ADAS Boxworth on-site testing facility

A new irrigation facility was installed at ADAS Boxworth in July 2015, which would allow new growing media blends to be tested on-site before then taking those products out on to grower holdings, for further testing. It was also used to gather data on how the current commercially available growing media perform. The facility contains six individual benches; 2 x ebb and flood, 3 x overhead irrigation and 1 x drippers. The facility was installed by Priva, and all benches are controlled via a Priva computer. Each bench is divided into four sections, which means that on one bench, there can be two different nutrient and irrigation regimes.

In order to test the facility, and make sure that any problems were eradicated before the testing of new blends began in 2016, a number of trials were set up in August 2015, covering potted herbs, hardy nursery stock and bedding plant and vegetable plugs. Growing media used in this first round of trials consisted of standard peat, reduced peat and peat-free products from each of the growing media manufacturers. Physical and chemical property analyses were also conducted on these materials.

Potted herbs

In August, seeds of parsley and coriander were hand-sown into square 9cm pots, which had been filled with the relevant growing media. Each pot contained 40 seeds. Pots were placed on one of the ebb and flood benches in a randomised order, and the parsley were covered with black polythene until germination. Pots were watered overhead by hand until germination, and then the ebb and flood bench was turned on, flooding for two minutes twice per day. The date of germination for each growing media treatment was recorded, and all pots were assessed for marketability. Height of the herbs was recorded and fresh and dry weight of the plant material was also assessed. The ebb and flood benches were very efficient and there were no problems noted. There were some differences however between the growing media treatments, most notably the peat-free products produced a smaller crop and the quality was not as good, for both parsley and coriander (**Figure iii** and ***Figure*iv**).

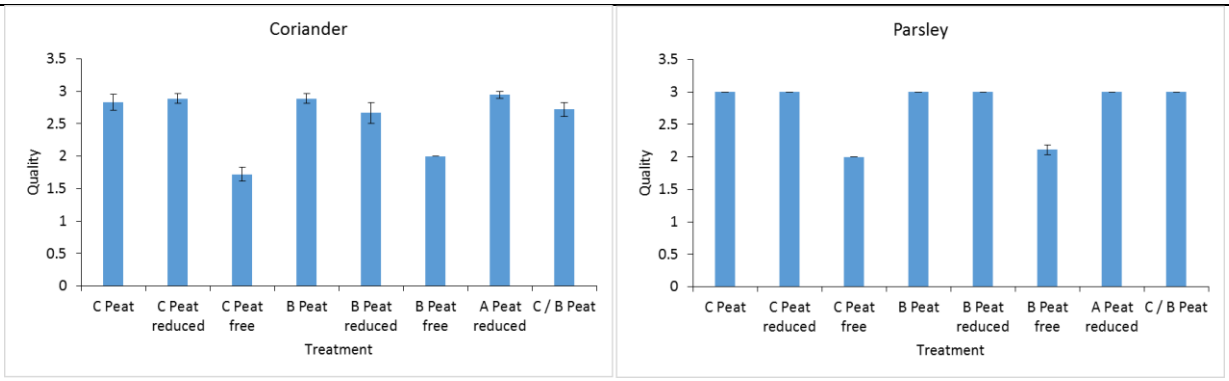
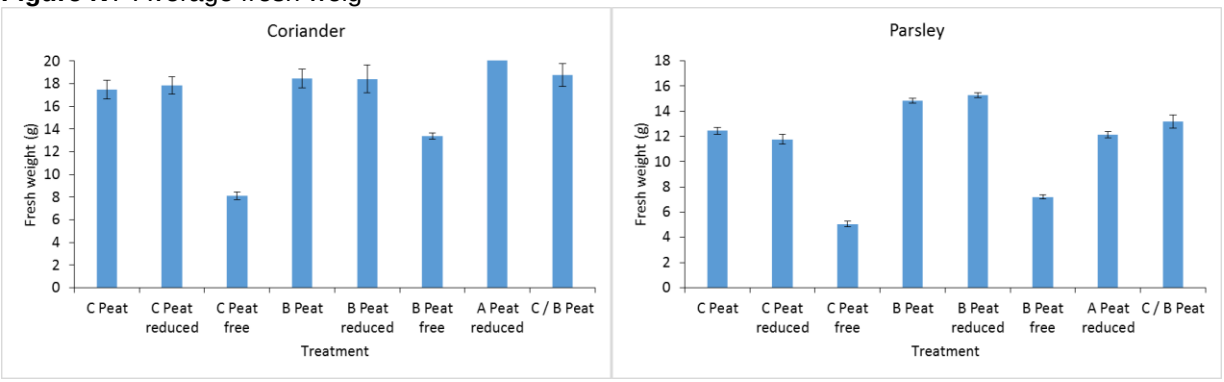


Figure iii. Average plant quality score, on a scale of 0-3, for coriander and parsley grown in various growing media blends.

Figure iv. Average fresh weig



ht of plant material in each pot for coriander and parsley grown in various growing media blends.

Hardy nursery stock

Plants of *Viburnum tinus* 'French white' and *Euonymus Emerald* 'Gaiety' were transplanted into 2 L pots filled with the relevant growing media on 11 August 2015, and set out in a randomised design on one ebb and flood bench, one dripper bench and one overhead sprinkler bench (larger nozzle size). Watering times and duration were altered to suit the weather conditions. The plants are still in place, and are growing well.

Bedding plant and vegetable propagation

Seeds of Pansy 'Yellow Blotch' were sown into 432 plug trays on 14 August 2015 and set out on one of the overhead sprinkler benches (smaller nozzle size). Watering was initially set to water twice per day for two minutes at a time, and this was then adjusted to suit the weather conditions. Germination in each growing media treatment was monitored.

For vegetable propagation, seeds of Cauliflower 'Skywalker' were sown into 360 plug trays on 11 August and set out on an overhead sprinkler bench (same nozzle size as the bedding plants). Watering was initially set to water twice per day for two minutes at a time, and this was then adjusted to suit the weather conditions. Germination in each growing media treatment was monitored, and at five weeks after sowing, the height of the plugs was recorded. Quality, fresh and dry weight were also assessed (**Figure** and **Figure vi**).

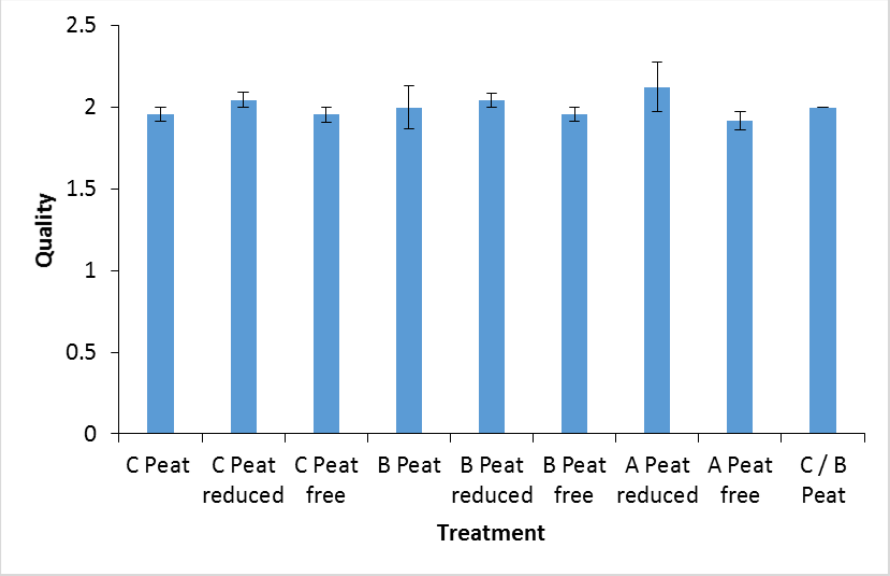


Figure v. Plant quality score quantified on a scale of 0-3 for cauliflower plugs grown in various growing media blends.

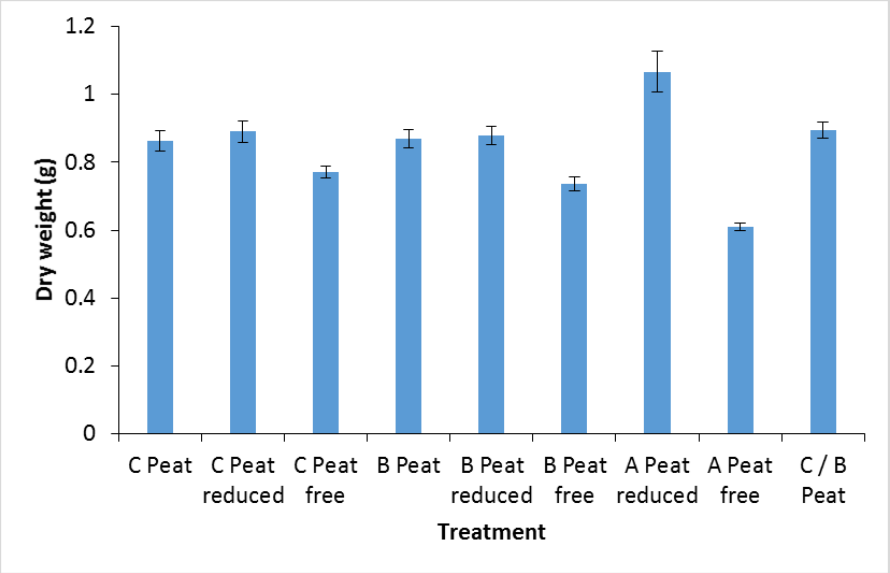


Figure vi. Dry weight of 10 cauliflower plugs per treatment for each of the growing media blends.

Plant quality was elevated in reduced peat products, compared with peat or peat-free growing media. Dry weight mirrored plant quality responses (**Figures v and vi**).

System development and data analysing for the growing media testing system pilot trial

There were some issues with watering on the bedding plant and vegetable propagation benches, as a small proportion of the tray area did not receive sufficient irrigation. The consensus view was that not only were the nozzles too small but more were needed on the bench, in order to get even coverage. Originally, the nozzles irrigated as a fine mist, but the decision was taken to change these to a larger droplet size so that irrigation would be more of a 'sprinkle', as is used on the HNS overhead sprinkler bench. It also became apparent that trials involving different types of growing media cannot be randomised together on a single bench / blocked area, as their watering requirements are different. For example, a peat-free product such as coir will require a lot more irrigation compared with a predominantly peat product. Therefore, the peat, reduced peat and peat-free blends will have to be positioned separately, so that their irrigation and nutrient requirements can be managed adequately, and tailored to suit each growing media type. This arrangement will be required for the ebb and flood benches and drippers as well. It may be that some of the differences seen in the trials between the growing media treatments may not have been so stark, if the media had been irrigated to its own individual optimum. The re-arrangement of treatments on a bench is easily solved, and the changes to the nozzles on the two overhead misting benches are being implemented by Priva.

For these reasons, full statistical analysis of these test data using indicator plant species was deemed inappropriate, until the test system was developed to an industry acceptable specification and the growing media types were grouped by irrigation and nutrient regime demand. Using a robust approach through experimental system development, will provide the platform to test differences in selected plant growth response to growing media type alone. We envisage that full testing capability will be running in early 2016, to trial prototype blends, prior to use on growing holdings in 2017.