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, Quadram Institute Bioscience and Stockbridge Technology Centre

4. Project Leader: Dr Barry Mulholland

5. Key staff: (name) Dr Barry Mulholland
(name) Dr Andrew Watson
(name) Click here to enter text.

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 In these cases, such information should be detailed in a separate annex (unpublished).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

Modelling

- Third generation materials and mixtures for experimental trials at Boxworth were selected. The philosophy was to once again use four key (or ‘basis’) materials that embrace as much parameter space as possible. Recognising the need to diversify from coir in addition to moving away from peat, and also recognising an interest from industry to ‘see something new’, all four materials are prototypes: one (M2) was actually predicted as a result of previous results from CP138. The four materials are known as M1, M2, M3 and M4 for reasons of confidentiality. They are also collectively termed ‘novels’. Boxworth trials have revealed that some of the mixtures are candidate peat replacements.
- A simple prototype mathematical model based on least-squares regression applied to Chinese cabbage data has been developed. The model has the form ‘weight = a + b*AFP (air filled porosity)’, where a and b are constants. Predictions of Chinese cabbage weight for mixtures based on other materials have been generated. The form of the model will evolve to take account of dry bulk density (D_b) effects that are becoming more visible using revised data collection methods which were utilised for the 2018 trials. Furthermore, the model will be developed to embrace other plant types.
- During 2018 the understanding of the CP138 approach, based on key parameters, has evolved. Specifically, CP138 involves factorial rather than classic mixing experiments, even though at first sight it seems to be a mixing experiment program. The distinction is important in understanding the impact of the universality of the CP138 approach compared with traditional stand-alone trials to assess the performance of growing media selections on the marketable quality of the grown product.
- A new visualisation, in which plant performance (fresh weight) is plotted as a bar chart of ranked plant response (as opposed to mixture number or parameter value) has proved useful. For example, herbs respond more sensitively to growing media selection compared with HNS plant types. This type of clear demonstration of what is probably anecdotally known in the industry is only possible because of the use of several plant types with identical growing media mixtures. This “performance range” has implications both for modelling and for policy.

Grower trials and knowledge exchange

- In the 2018 grower trials, 2nd generation peat-free growing media blends which were selected for their more ‘extreme’ physical properties and which performed well in the experimental trials were carried through to commercial trial assessment. Of the four blends selected, two produced plants that were comparable with the nursery standard product across the different crop sectors (bedding and vegetable propagation).

- The 1st generation peat-free prototypes from the 2017 grower trials were tested again in 2018 for consistency, alongside the 2nd generation blends. All performed well, with results similar to those seen in 2017 demonstrating consistency across sites, plant types and growing season.
- The 2018 experimental trials took a different blend selection approach, utilising raw materials supplied by the GMM's which were new to the project. The blends created gave mixed results in pot chrysanthemum, herb and HNS production, however there were some promising blends which can be taken forward for commercial testing in 2019. This work has demonstrated that modelling can be used to design new growing media products that are acceptable for use in commercial UK horticulture plant production systems.
- Knowledge exchange is an important function of CP138 to ease the transition, if required, from a dependence on peat to the use of other high performing growing media products. To date 1245 Horticulture Industry professionals have attended CP138 independent on site grower workshops or heard the CP138 delivery team present at organised industry events.

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 alternative 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, plus peat, are categorised as potentially 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 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 mean dependence on a single raw material type. It is appropriate on a sustainable availability, supply, performance and cost basis to mix up to four raw materials in a "blend", to produce commercially acceptable "peat alternative" plant products in containers and blocks. 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

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[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 Quadram Institute Bioscience and Stockbridge Technology Centre.

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 alternative material blends, 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 alternative materials that can perform as well as, 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 i**). 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).

The key features of the project are summarised as follows:

- Five year co-innovation project, funded by Defra, AHDB Horticulture, growing media manufacturers (GMM's) and growers to move towards an 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.

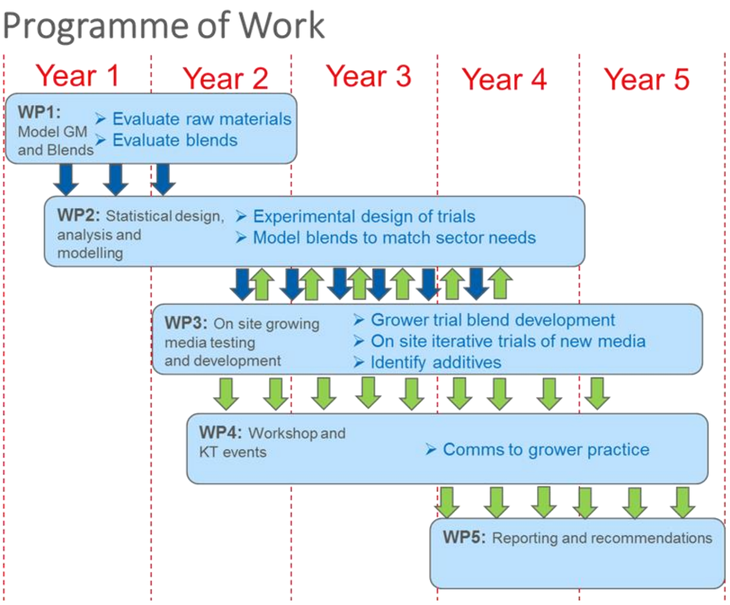


Figure i. Programme of work across the 5 year project. **WP1** has been completed, **WP2, 3** and **4** run throughout the project. Each WP consists of a number of agreed specific tasks.

Summary of findings

Overarching description of work reported

The main activities and outputs for **WPs 2, 3** and **4** will be described in the following sections. **WP2** is integral to all practical work carried out in **WPs 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. This project is iterative, where the modelling informs experimental design and data produced informs the model. Significant and important insight has been secured for the ability of CP138 to deliver a model that can be used to design robust commercial growing media products. This will potentially create diversity in the market based on a number of key parameters (raw material availability linked to price, growing system and plant type) to mitigate risk for the Horticulture industry and avoid the reliance on a single main raw material for containerised production. The project is on course to meet the core Objectives and provide a new and important tool for the industry to respond rapidly and robustly to policy and market demands for the transition to responsible sourced growing media.

Progress against work plan for WP2

Stand-alone trials of growing media, which are industry standard practice, are limited in their ability to predict plant performance if the raw material changes from time of testing to commercial distribution and use. The method is expensive and time consuming. Their outputs are also not transferable, in the sense that the knowledge gained cannot usually be easily used to inform other trials with the same plants but a different growing media, or different plants in the same growing media. Even the meaning of ‘same’ and ‘different’ growing media is not clear. For example, imagine a trial based on 30% peat combined with 70% wood fibre used successfully to produce a hardy nursery stock species such as *Choisya*. The exact same growing media may not give good results for a different plant, for example viola. Or, a repeat trial also using 30% peat and 70% wood fibre from different suppliers but again with *Choisya* could give a very different outcome for reasons that are apparently mysterious. Finally, trials conducted without measurement of the substrate parameters amount to using the plants themselves as detectors. A failed trial merely means something is wrong but gives little clue as to what the problem might be.

Modelling based on key parameters will not replace growing trials entirely but will help inform the selection of trials, provide a framework upon which to quantify our understanding of success or failure and assist in transferring insight between trials.

Our understanding of the modelling aspects of the project do however continue to evolve. In particular, it is important to understand that this project is based on factorial experiments, not mixture experiments. In a *mixture experiment* the measured *response* is assumed to depend solely on the relative proportions of the different *components* that comprise the mixture. In contrast to a mixture experiment, in a *factorial experiment* the measured response is assumed to depend on the variation in two or more *factors*. This is an important distinction which has informed the modelling process so far; modelling progress is considered in **WP2**, below.

WP2: Statistical design and analysis of growing media experiments and multivariate modelling (Tasks 2.1-2.1.4).

In a *mixture experiment* the measured *response* is assumed to depend solely on the relative proportions of the different *components* that comprise the mixture. If the mixture contains at most *n* components and each component occurs in the proportion λ_i then

$$0 \leq \lambda_i \leq 1 \text{ for } i=1, 2 \ldots n$$

and

$$\sum_{i=1}^{n} \lambda_i = 1$$

The first relation states that all proportions are positive and assume a value between 0 and 1. The second relation states that the sum of all proportions is unity, the total mixture. Geometrically, the single component instances of all possible mixtures of *n* components correspond to *n vertices* of a region whose interior, boundaries and vertices embrace all possible component combinations satisfying the above constraints. Note that the constraint $\sum_{i=1}^{n} \lambda_i = 1$ means that only *n*-1 of the *n* components can be varied independently. For a three-component mixture, for example, two of the components can be varied independently of each other but the third cannot, since the constraint must be satisfied.

In contrast to a mixture experiment, in a *factorial experiment* the measured response is assumed to depend on the variation in two or more *factors*. An example of a factorial experiment would be a study of plant height with respect to two factors, temperature and added fertiliser.

There are some important distinctions between a mixture experiment and a factorial experiment. In a factorial experiment there are no generic constraints on the factors corresponding to the $0 \leq \lambda_i \leq 1$ and $\sum_{i=1}^{n} \lambda_i = 1$ constraints on proportions in a mixture experiment. The *n* factors in a factorial experiment can be varied independently whereas for a mixture experiment only *n*-1 of the *n* mixture components can be varied independently.

The variables over which we have direct control are the proportions of the different component materials, termed *basis* materials since all mixtures are constructed from these materials. We do *not* have direct control over the parameters AFP (air filled porosity), D_b (dry bulk density) and AW (available water). These are therefore classed as *hidden variables*. We can access points in the parameter space AFP, D_b and AW only by constructing mixtures with various proportions of basis materials.

The proportions λ_i not only by definition express the fractions of the different components in a mix, they also express the level of some mixture attribute *a* in terms of the contributions a_i from component *i*. It is assumed that the a_i combine linearly such that

$$a_{mix} = \sum_{i=1}^{n} \lambda_i a_i$$

where once again $\sum_{i=1}^{n} \lambda_i = 1$ and $0 \le \lambda_i \le 1$ for *i*=1, 2 … *n*. Significantly, given the assumptions, the proportions λ_i from the original mixture experiment restrict the space of values of attributes such as *a*, assuming a linear sum is appropriate for a_{mix}.

The fact that our experiments are factorial rather than classic mixing experiments has the important consequence that all the machinery developed to analyse mixing experiments in terms of canonical polynomials based on mixing designs and simplex lattices is no longer applicable. The core of this is the lack of a constraint of the form

$$\sum_{i=1}^{n} \lambda_i = 1$$

available in the mixtures case: values of the physical parameters are not bounded, though the proportions in a mixture are. This is also the reason why ternary plots (typified by 'soil plots') are not helpful. However, the constraint on mixture proportions does mean that attribute combinations AFP, D_b and AW are convex. Further, because our approach is based on a fixed number of basis materials the mixture proportions constrain the available parameter space.

A simple route to examine the dependence of a 'response variable', such as plant height or quality, on predictor variables, which include AFP, D_b and AW, is via the method of least squares. Assuming a relationship does indeed exist between predictor and response, the least squares approach creates a model by minimising the sum of the squared differences between actual data points and trial model lines. Several predictor variables can be included as needed. Here and in subsequent reports we will follow the standard notation of the form R ~ P1 + P2 + P1*P2 for response R and two predictors P1 and P2. An intercept term is assumed in the model and not made explicit. The terms P1 and P2 are simple predictor variables to the power unity. The P1*P2 term accommodates interaction between P1 and P2. This method of estimating the relationship between the response and predictor variables is a form of regression analysis. It has the advantages of simplicity, ease of implementation, and simple interpretation of the outcome.

Fifteen trial models have been explored for Chinese cabbage plug plants using fresh weight values (averaged over 10 plug plants) from Boxworth trials in the 2017 growing season. The trial growing media was the second generation ('samosa') selection based on bark, coir, green compost and wood fibre. The statistically most successful model was 'Weight ~ AFP', with intercept value 40.68 and regression coefficient -0.536, in other words

$$W = 40.68 - 0.536AFP$$

Here, *W* is the fresh weight.

The experimental data for Chinese cabbage is shown in **Figure 1**, where the D_b dependence has been supressed. The corresponding model output is shown in **Figure 2**.

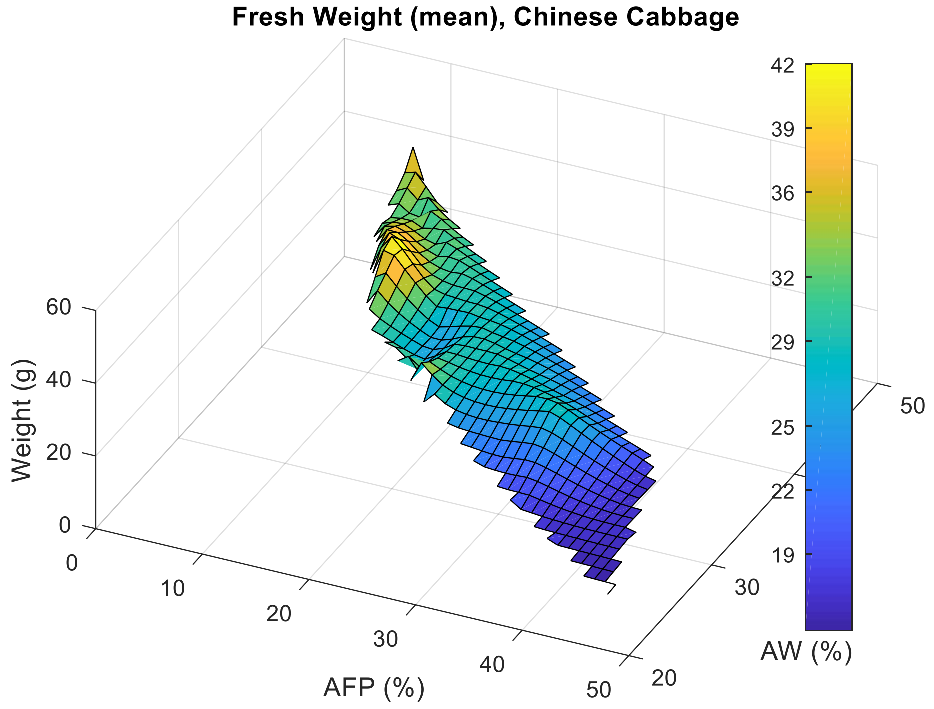


Figure 1. Chinese cabbage mean fresh weight experimental data, Boxworth trial, second generation ('samosa') growing media. The colour bar indicates the average fresh weight value.

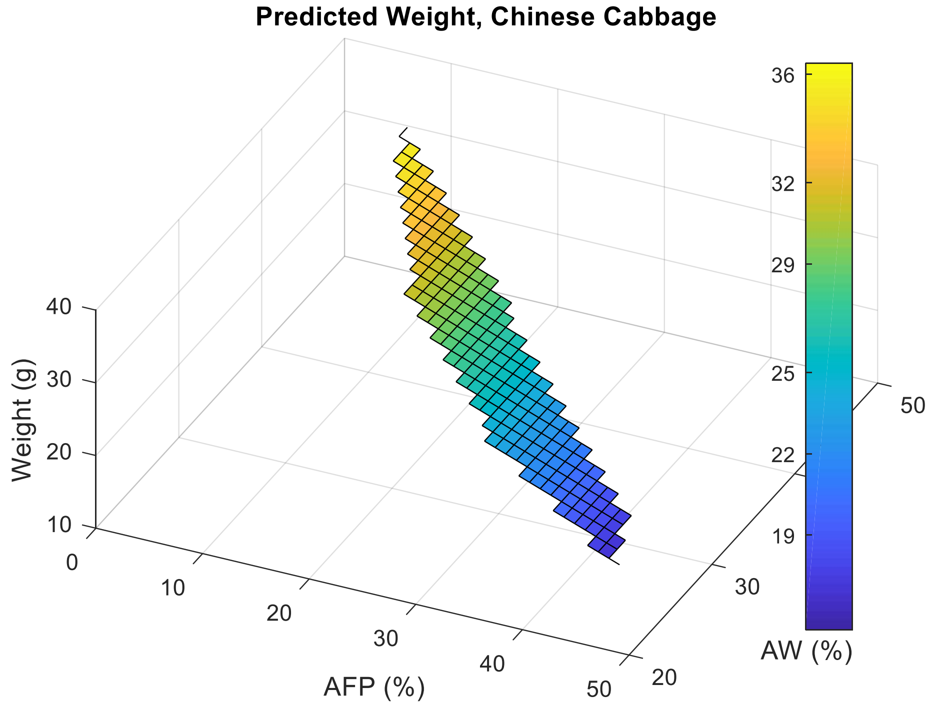


Figure 2. Modelled Chinese cabbage weights according to the model described in the text.

The model can be used to generate predictions. For example, a 50:50 bark and woodfibre mix using values from the 2015 back catalogue of data, inserted into the model, predicts a cabbage weight of 21.5 g ± 3.5 g (95% confidence limits).

The model is noteworthy for its simplicity, since it depends only on a constant and a single parameter, AFP. Note that AW and D_b do not feature. A dependence on AFP (where small AFP values correspond to good plant response) is consistent with expectation. The absence of AW is linked to the high correlation between AFP and AW over the parameter range explored. The absence of D_b is likely to be linked to inadequacies in the data, which show only a weak correlation between weight and D_b. Improved data will be extracted from the 2018 trials using fresh weight values and individual plant data. Exposing the need for more detailed data collection of this type is an output of the project.

Future versions of the model are likely to be more complicated than the simple Chinese cabbage model presented here, which can be considered a prototype.

The raw material for the modelling effort is the experimental trials. Mixture selection for Boxworth 2018 experimental trials followed the same philosophy as the selection for the previous year, namely the selection of materials widely separated in their physical properties so as to span as much of the parameter space as possible. In addition, acknowledging industry's concerns regarding possible long-term over-reliance on coir, and the existence of alternative materials from the growing media manufacturers, the decision was made to employ so-called 'novel' materials as the basis materials for the third generation. For reasons of commercial sensitivity these materials are designated M1, M2, M3 and M4. None of these materials are peat or coir, and none are currently widely used in the industry. Material M2 is a prediction from earlier results in this project.

The physical properties of these materials are summarised in **Table 1**, and the mixtures used are shown in **Table 2**. The measured physical properties for the experimental prototype blends are shown in **Appendix 7**.

Table 1. Values of the four parameters Air Filled Porosity (AFP), Dry Bulk Density (D_b) and Available Water (AW) for the four selected basis materials, third generation.

	AFP	**D_b**	**AW**
M1	44.76	0.083	27.23
M2	16.23	0.203	31.16
M3	20.63	0.120	52.38
M4	12.49	0.183	27.65

Table 2. Mixture table for the third generation Boxworth trial materials ('novels' series). In addition, there is a peat reference (Mix No. 1). Mixes are selected to give a broad range of parameter space cover, hence the emphasis on two-component mixtures.

Mix No.	**M1**	**M2**	**M3**	**M4**
1	0	0	0	0
2	1	0	0	0
3	0.66	0.33	0	0
4	0.66	0	0.33	0
5	0	1	0	0
6	0.33	0.66	0	0
7	0	0.66	0.33	0

8	0	0	1	0
9	0.33	0	0.66	0
10	0	0.33	0.66	0
11	0.66	0	0	0.33
12	0	0	0	1
13	0.33	0	0	0.66
14	0	0.33	0	0.66
15	0	0	0.33	0.66
16	0	0.66	0	0.33
17	0	0	0.66	0.33
18	0.33	0	0.33	0.33
19	0	0.33	0.33	0.33

The measured physical parameters of the mixtures are plotted in three dimensions (**Figure 3**). The four basis materials define four vertices of a tetrahedral region, with edges linking the vertices. According to simple linear addition of mixtures, as described in the CP138 Year 3 Annual Report, all mixtures might be expected to lie within this region or on its boundary edges and faces. In fact, though it is not immediately clear in the three-dimensional figure, half of the mixtures lie outside the tetrahedral region, and half on or within the region.

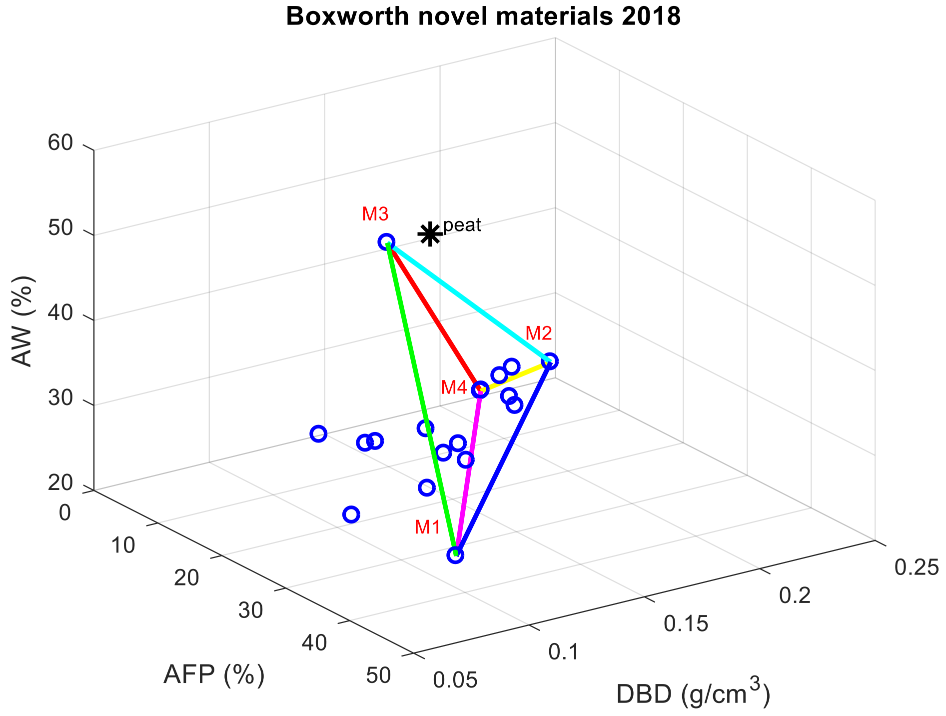


Figure 3. The four basis materials (the vertices, labelled M1 to M4) of the third generation materials, plotted against physical parameters AFP, D_b, and AW. Blue circles not at vertices show measured values of mixtures blended according to the mixture table above. The peat reference is shown in black.

The implied departure from simple linear mixing can be more systematically appreciated using a bar chart that compares measured parameter values with predicted values, **Figure 4** below. The predictions are obtained using the measured parameters of the raw materials used in the trial and reproduced in **Table 1** above, combined with the combinations as listed in **Table 2**.

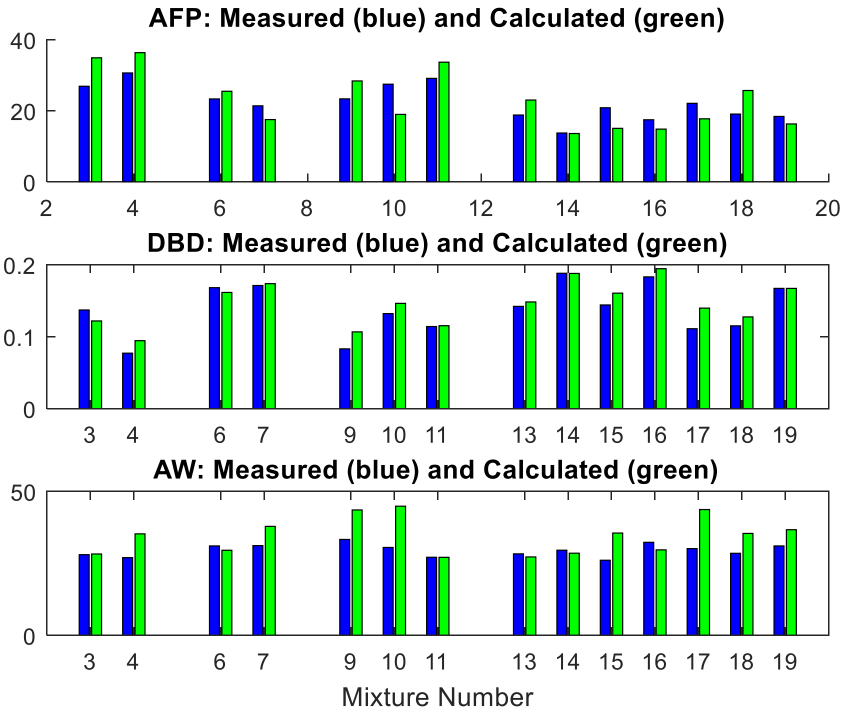


Figure 4. Measured and calculated values of the three parameters for the mixtures comprising the 'novels' series. The gaps are due to peat (1) and the four basis materials, for which comparisons do not exist.

In **Figure 4** a difference in the height of corresponding blue and green bars indicates a mismatch between measured and predicted values for that parameter and that mixture. The agreement is broadly comparable to that obtained for the second generation ('samosa') series presented in the Year 3 report. A feature of the current data is the relatively poor agreement between measured and predicted AW values for mixtures 9, 10 and 17, all three of which comprise 2/3 material M3. The implication is that there is a systematic difference associated with this material, a point to be discussed further below. Regarding the other parameters, D_b shows similar levels of agreement for both second and the current generation, and AFP is possibly somewhat better in the current third generation data.

It is worthwhile introducing some perspective on these results that is important in terms of model output and interpretation of that output. The selection of basis materials is made on the grounds of measurements of the physical parameters of candidate materials. Once the selection has been made, new shipments of those materials are sourced in sufficient quantities to conduct growing trials. The parameters of these new shipments (the basis materials) are re-measured (cf **Table 1**) but these new measurements are found to be different from those obtained at the decision stage. This is illustrated in **Figure 5**, which shows the basis materials used for the third generation ('novels') as blue circles linked by solid lines. These circles are to be compared with the set linked by dotted lines (using the same colour codes for the lines) which show the values of these materials as determined from earlier shipments of the 'same' materials. It is these earlier measurements that were used when deciding which materials and mixtures to use. In an ideal world the two sets of blue circles should be coincident. Clearly they are not, reflecting the natural variation in parameter values between shipments.

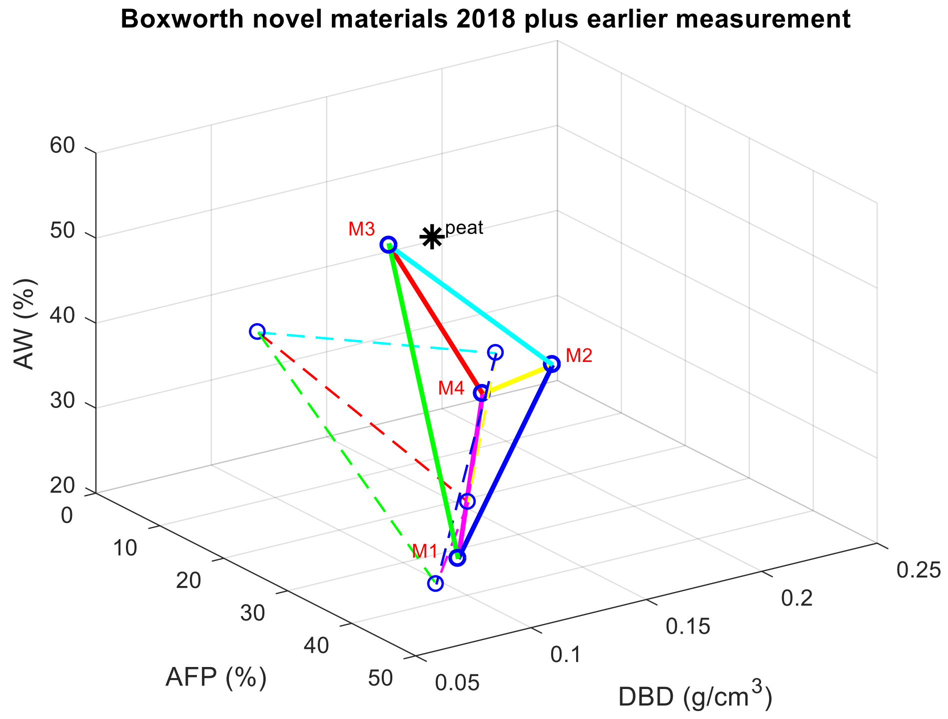


Figure 5. The basis materials of the third generation ('novels') series materials (blue circles joined by solid lines), compared to earlier instances of the same materials joined by dotted lines.

The plants trialled at Boxworth over the 2018 season were chrysanthemum, basil, coriander, rosemary, griselinia and viburnum. Plant fresh weight data for each of the mixtures is displayed below for coriander and viburnum (**Figure 6 - Figure 9**).

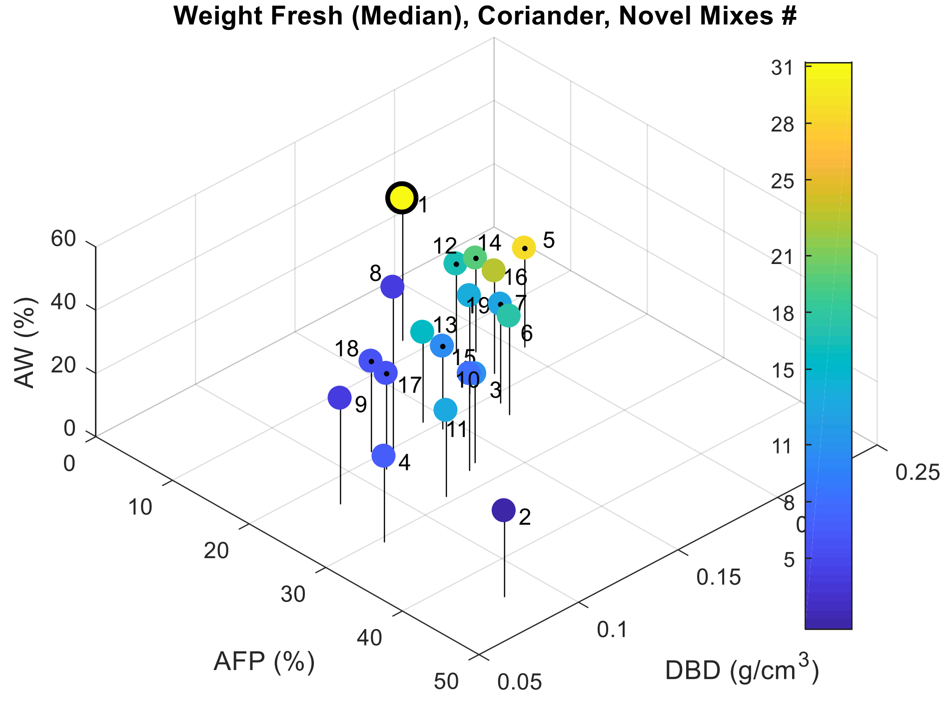


Figure 6. Coriander, median fresh weights (g) versus the parameters (AFP, D_b (DBD), AW), third generation ('novels') mixture series. The coloured circles are different mixtures (as numbered) and are assigned a colour from blue to yellow, where yellow is high performing and blue is poor performing. The peat standard is a black-bordered open circle.

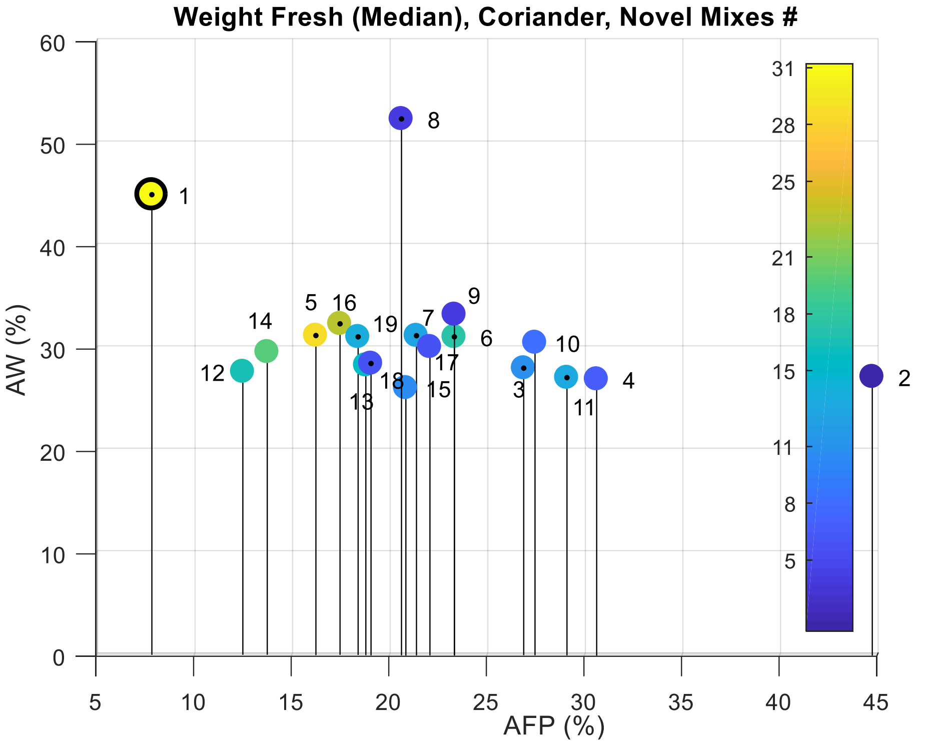


Figure 7. Coriander (g), as for **Figure 6** but rotated to suppress the D_b axis.

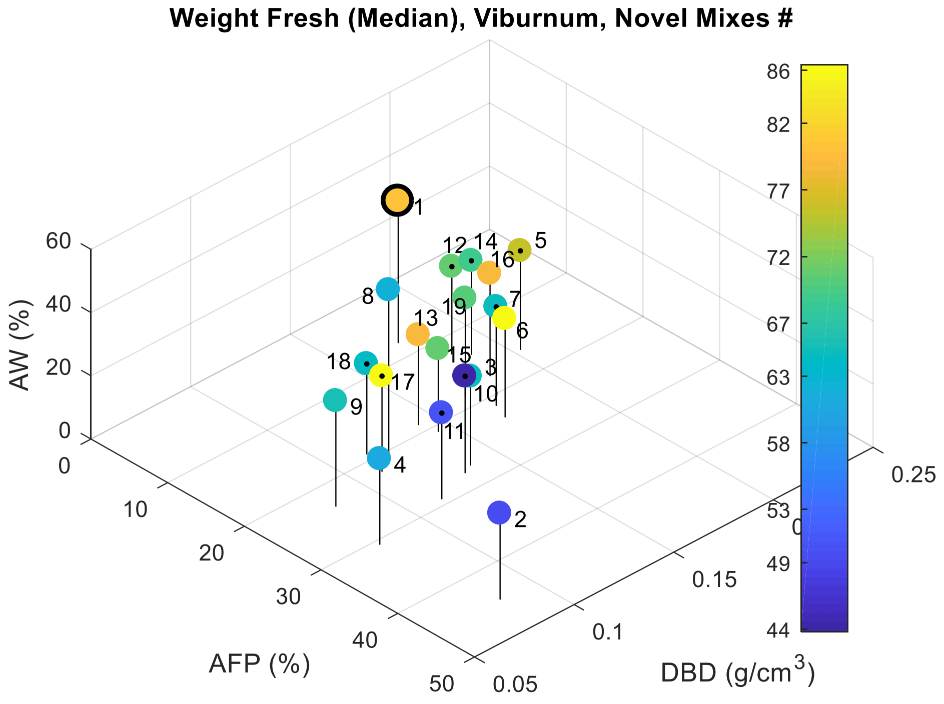


Figure 8. Viburnum, median fresh weights (g) versus the parameters (AFP, D_b (DBD), AW), third generation ('novels') mixture series. The coloured circles are different mixtures (as numbered) and are assigned a colour from blue to yellow, where yellow is high performing and blue is poor performing. The peat standard is a black-bordered open circle.

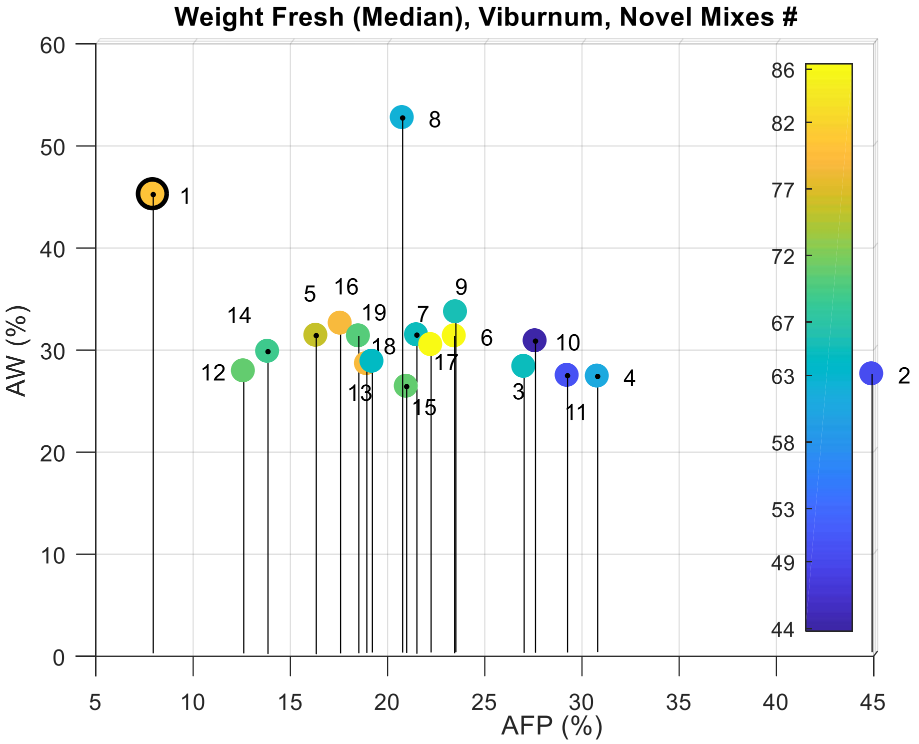


Figure 9. Viburnum (g), as for **Figure 8** above but rotated to suppress the D_b axis.

Data from the other Boxworth trials showed a similar structure.

The most conspicuous feature in **Figure 7** and **Figure 9** is the point associated with mix 8 (pure M3). This point sits above the main cluster, reflecting the fact that M3 has a very high AW value, so this location above most of the mixture points is consistent with the location of the M3 point in **Figure 3**. It is a consequence of M3 failing to raise the AW values of mixtures rich in M3. Also interesting is the fact that plant performance for M3 is mediocre. The M3 material is behaving like a material having an AW value of around 30. This material in contrast to the other growing media types was not composted prior to use and is clearly behaving differently.

The colour coding helps to see how well plants perform with different mixtures, but it does not fully reveal an important property of the plant performance data. **Figure 10** and **Figure 11** below show coriander and viburnum data once again, but this time simply the fresh weights displayed on a bar chart, with the bars ordered according to increasing plant weight.

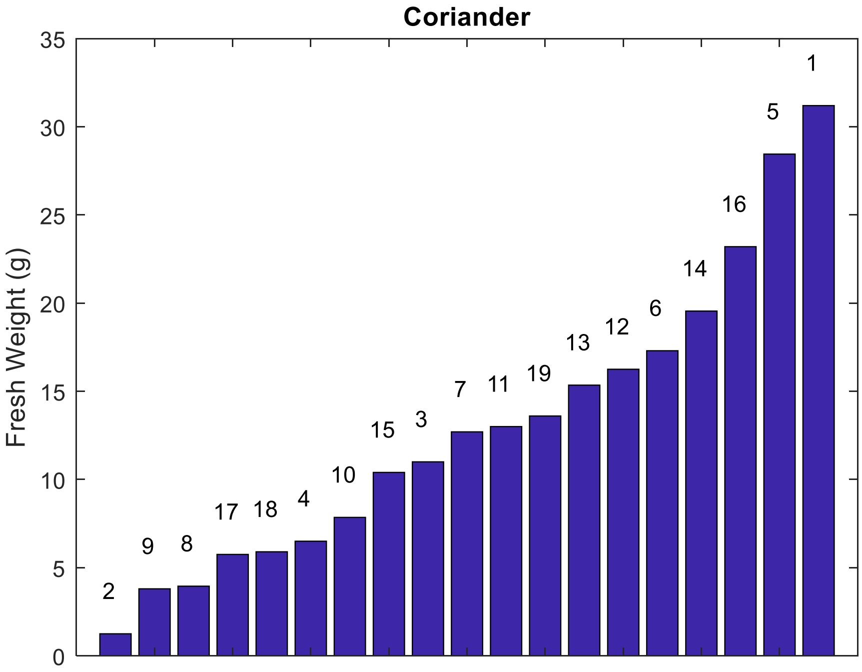


Figure 10. Coriander, fresh weight data for third generation (‘novels’) mixtures, Boxworth trials, ranked according to increasing weight. This weight data is the same as that used in Figure 6. The top three performing mixtures in increasing order are 16, 5 and peat.

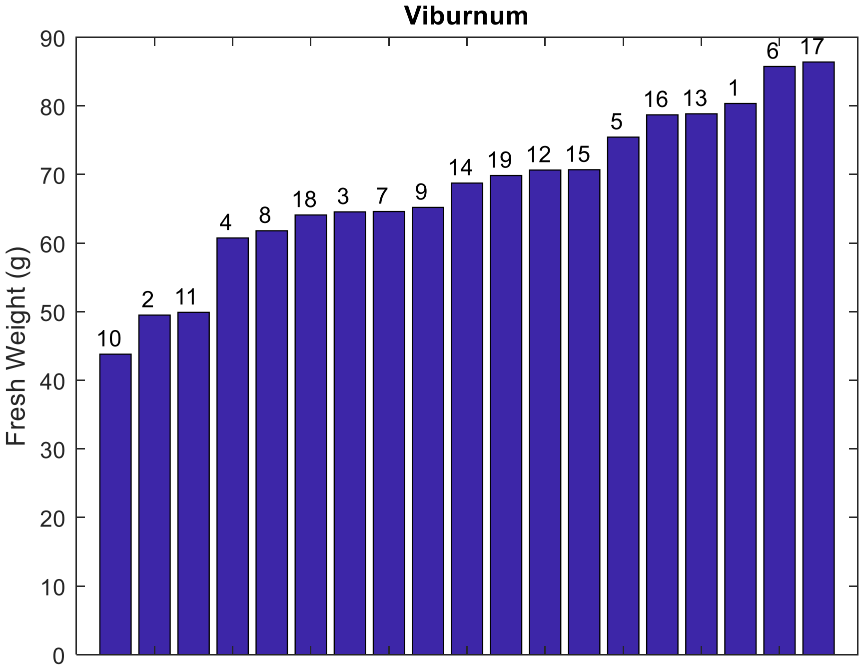


Figure 11. Viburnum, fresh weight data for third generation (‘novels’) mixtures, Boxworth trials, ranked according to increasing weight. This weight data is the same as that used in Figure 8. The top three performing mixtures in increasing order are peat, 6 and 17.

The visualisation in **Figure 10** and **Figure 11** is new and is quite informative. Comparing the two it is clear that coriander is much more sensitive to different mixtures than viburnum *over the course of the trial*. Note that the other herbs in the trial (basil, rosemary) show the same pattern as coriander, as does chrysanthemum. Griselinia shows the same pattern as viburnum. It is also clear that some mixtures perform at a level comparable to peat. Recall that, apart from the peat reference none of the mixtures contain peat or coir, yet some appear viable as peat replacements.

A rough and ready way to capture the difference in response to different media in a way that permits some degree of comparison is the ratio:

$$R = \frac{(max - min)}{(max + min)}$$

This is simply a normalised difference. In the present case R applies to fresh weight values but it could also be other performance parameters such as height. When $R \sim 0$ then there is essentially no dependence on mixture. When $R \sim 1$ then the dependence on mixture is large. Note $0 \leq R \leq 1$. Using the data displayed in **Figures 10** and **11** gives:

R_{weight} (coriander) = 0.92 R_{weight} (viburnum) = 0.33

To some extent the overall usefulness of the visualisation in **Figure 10** and **Figure 11**, and the values of R, depend on how much of the lifetime of the plant is being sampled. The data for chrysanthemums and the three herbs was collected over a time span equal to that used by a commercial grower. The viburnum and griselina trials started with commercial quality young plants. At the end of the trial the plants were *close* to being acceptable as a commercial product.

From the modelling perspective what is useful is a strong trend of plant performance with mixture since a trend is easier to spot if the span of outcomes is greater. Therefore, modelling will be more likely to be of greater functional use for plants such as herbs and chrysanthemum which display a strong dependence on mixture composition and where fine tuning of a mix is critical to marketable quality. It has become clear that the modelling output cannot be directly applied to other plant types, though the suggestion is that plants within groups may share the same model.

There is a practical element flowing from **Figure 10** and **Figure 11**. The suggestion is that some plant types, such as viburnum, are more tolerant of the growing media than others. This gives scope for potentially using cheaper mixes, or switching to other mixes for reasons of sustainability or availability. Assuming this pattern is replicated for other plant species, it also supports the idea of rolling out peat-alternative mixes to some plant types, such as viburnum, before others, such as herbs, since the former are more likely to succeed more easily while the industry builds confidence and capacity.

It is important also to note that the type of comparisons shown in **Figure 10** and **Figure 11** are only possible because different plants have been grown in identical sets of mixtures. This is a feature and a strength of the current project.

Boxworth trials conducted during 2018, using third generation (‘novels’) mixtures, have revealed the project’s best evidence yet for a link between plant performance and D_b, due at least in part to improved data collecting. **Error! Reference source not found.** shows the dependence of coriander fresh weight on D_b:

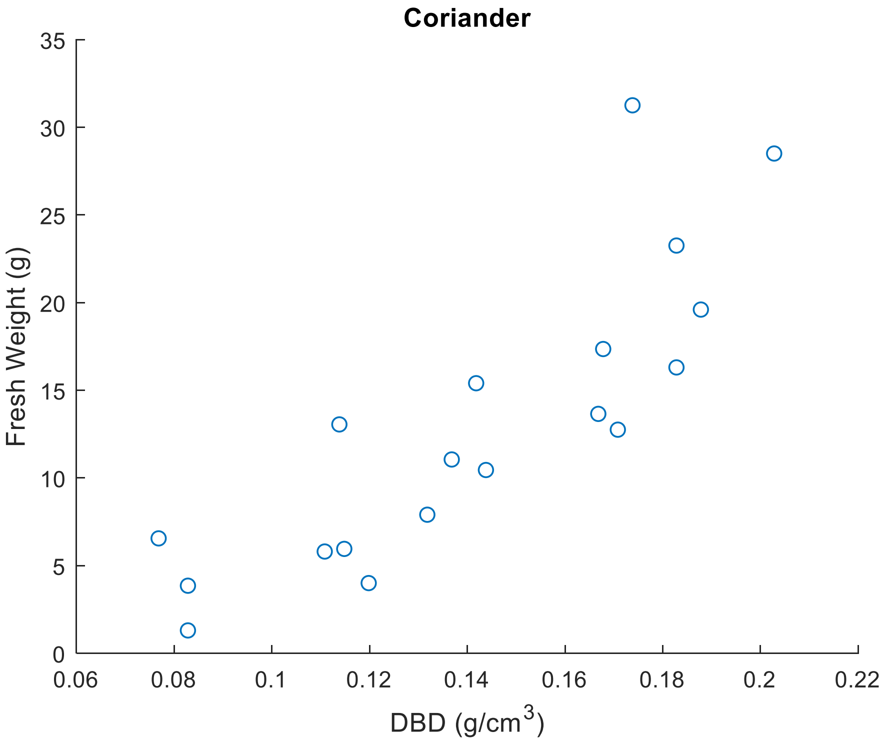


Figure 12. Coriander, fresh weight versus D_b (DBD), Boxworth trials with third generation ('novels') mixtures, using the same data as **Figure 6**.

The other herbs (basil and rosemary) show a similar trend, chrysanthemum a little less strongly. For griselinia and viburnum the trend is weak (correlation coefficients 0.65 and 0.49, respectively, compared to 0.84 for coriander). The dependence on D_b will be considered as part of trial models going forward.

WP3: On-site growing media testing and development

Approach summary

During 2018, trials were conducted both on grower sites and at the experimental site of ADAS Boxworth (**WP3**, **Tasks 3.1-3.4**). There were also some grower trials from 2017 which had overwintered, and were concluded in early 2018. Each trial has been summarised below, and further information can be found in the Appendices. All experimental work has been informed by the outputs of **WP2**. Plant performance in prototype growing media blends were tested in "pre-campaigns" at ADAS Boxworth and the best performing growing media were tested under commercial conditions at hosted grower sites and were termed "main campaigns". All data were analysed using Analysis of Variance (ANOVA) with use of Duncan's multiple range test to separate treatments. The test was used with a 95% confidence level.

2017 First generation prototype blend testing – overwintered trials on grower hosted sites

During 2017, trials were carried out on six grower sites. The completed trials were reported in the CP138 Year 3 Annual Report, however, trials on three of these sites overwintered into 2018 (**Table 3**) and therefore are being reported in the Year 4 Annual Report. Each trial consisted of three peat-free prototype blends (Prototypes 1-3) which were originally tested at ADAS Boxworth in 2016, plus the nurseries' standard product, resulting in four treatments per trial. For the cane fruit and soft fruit trials, an additional coir-free growing media treatment was used. This treatment was deemed successful in the 2016 strawberry trial at New Farm Produce, and was supplied by one of the GMMs. Prior to the trials commencing, nutrition levels for each crop were agreed with the host grower, so that each prototype blend had the same concentration of nutrients applied at a set pH. This was to ensure that any observed differences were due to the growing media blend and not nutrient availability. The prototype blends plus the standard nursery blends were also tested for physical and chemical properties.

Table 3. Overwintered grower hosted trials in 2017.

Host	Trial	Duration
EU Plants	Raspberry prop	Planted week 15, 2017.
EU Plants	Strawberry prop	Planted week 28, 2017.
F P Matthews	Top fruit	Planted week 12, 2017.
Lowaters	HNS Finals	Planted week 11-22, 2017. *Salvia* completed week 22, 2017. Other species overwintered into 2018.

Cane fruit propagation – raspberries

Methods

Trials were carried out at EU Plants Ltd (Finchampstead, RG40 3TS) using propagated raspberry material of Glen Ample and Maravilla, from April 2017 until June 2018. Five growing media treatments were used and these were replicated eight times, to give a total of 40 plots per cultivar, which were set out in a randomised trial design (**Appendix 1**). No base dressing was added to any of the growing media used in this trial, as it would be supplied in the irrigation water.

The raspberries were planted into 84-cell trays for the initial propagation stage in week 15 2017, with one tray per plot, giving a total of 672 plants per treatment, per cultivar. Each tray was hand-filled with the relevant growing media, labelled and wet-up by sprinkler before planting. The plant material was hand stuck by nursery staff to ensure that all trays were even and to a commercial standard. The trays were placed alongside the nurseries' commercial crop, on plastic pallets to prevent them from touching the floor, and the plants were grown on within a polythene tunnel, with overhead irrigation.

In week 21 2017, the trial was assessed for the number of leaves per plant, plant height, plant quality (scale of 0-5) and root development (scale of 0-5) for four plants per plot. For scoring criteria see **Appendix 1**. A sub-sample of the raspberry plants were then transplanted into 2 L pots(two plants per pot) for growing on, using the same media that they had been propagated in (**Figure 13**). Each plot contained one pot holding two plants, with each treatment replicated eight times, resulting in 16 plants per treatment, per cultivar. The plants were grown on in the field in a fully randomised trial design, with the pots set-down on one of the commercial lines, with mypex covering the soil. The trial was watered and fed via drip irrigation. Plants were treated for pest and disease as appropriate, following the standard practice of the nursery.

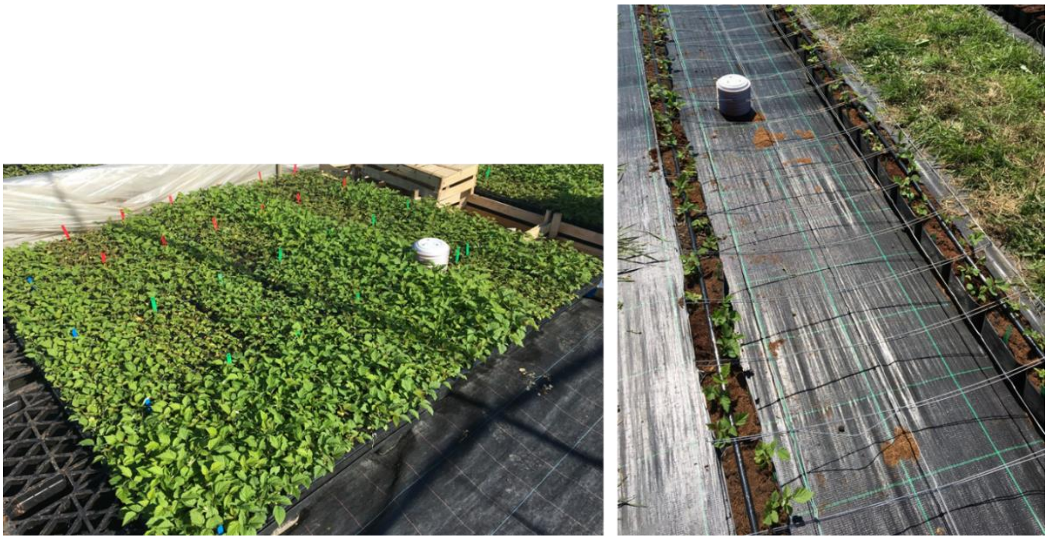


Figure 13. Trays of raspberries ready for transplanting (left) and plants transplanted 2 L pots (right), week 21 2017.

The trial was assessed at six, 12, 18 and 30 weeks after transplant, for height, quality (scale of 0-5; **Appendix 1**) and the number of nodes per plant, on one plant per plot. Plants were tagged so that the same ones could be assessed each time. In week 51 2017, Maravilla were assessed for the length of plant with bud break, rather than the number of nodes, and all plants were then placed into cold storage for the winter. The plants were grown-on as an observational trial in 2018 at Rectory Farm (Oxford, OX33 1HF) from March to August 2018. All plants were grown in coir-filled pots.

Results

Glen Ample

Pre-transplant

In week 21, there were no significant differences between treatments for the number of leaves per plant; all plants had three true leaves. Quality of the plants was significantly different (p <0.001, l.s.d = 0.2889), although all treatments scored greater than 3.0, the baseline for acceptable quality. Plants grown in the coir standard received the highest quality score (4.91), and those grown in the coir-free blend received the lowest quality score (3.50). The nursery standard scored significantly higher than all of the experimental treatments, although there was no significant difference between the three prototype blends, they were all very similar.

The trends for quality were reflected by plant height, with significant differences between treatments (p <0.001, l.s.d = 1.2094). The largest plants were produced by the nursery standard growing media (13.0 cm), which was significantly taller compared with all treatments. The shortest plants were produced in the coir-free blend (5.76 cm), this was significantly shorter than all other treatments. As with the quality, there were no significant differences between the three prototype blends; heights ranged from 8.94 cm to 9.51 cm.

There were also significant differences between treatments for root development (p =0.007, l.s.d = 0.3354, **Figure 14**). The nursery standard scored 4.0, with an extremely well developed root system. Prototype 2 scored 3.75 and this was not significantly different compared with the nursery standard. All other treatments scored significantly lower, with the lowest root score of 3.41 assigned to the coir-free treatment.

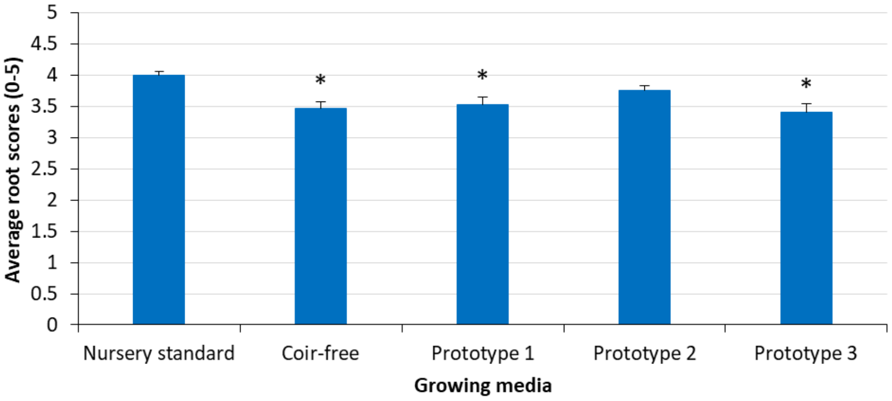


Figure 14. Average root scores for Glen Ample grown in different growing media blends at transplant, week 21, 2017. Differences across treatments are statistically significant (p <0.001, l.s.d = 0.3354). Error bars represent 1 standard error, with 4 degrees of freedom (d.f.). * = treatments are significantly different to the nursery standard.

Post-transplant

At six and 12 weeks after transplant, there were no significant differences between treatments. All plants were robust with new green growth; all treatments scored 4.0 for quality. At the third assessment however, 18 weeks after transplant, differences between treatments were observed and were significant (p <0.001, l.s.d = 0.4539). Prototype 3 received the highest quality score of 5.0, and the nursery standard scored 4.88. The coir-free blend scored 3.63 and this was significantly lower compared with all other treatments. Differences between the nursery standard and the three prototype blends were not significant.

The height of the plants between treatments was significantly different at each assessment date. Six weeks after transplant, the nursery standard was significantly taller than all experimental treatments (61.75 cm; p <0.001, l.s.d = 3.977), and the coir-free plants were the shortest (52.12 cm). Differences between treatments showed a similar trend 12 weeks after transplant (p =0.001, l.s.d = 7.91). The nursery standard was still the tallest (128.8 cm), and the coir-free blend was significantly shorter than all other treatments (112.0 cm). At the third assessment 18 weeks after transplant, although there was no significant difference between the nursery standard and the three prototypes, all three prototypes were now taller than the nursery standard, with the tallest plants growing in prototype 3 (172.8 cm). The nursery standard measured 169.1 cm, and the coir-free blend was significantly shorter compared with all other treatments (142.4 cm; p =0.002, l.s.d = 15.97). The plants were topped a few weeks prior to the final assessment, 30 weeks after transplant, although differences still showed the same trend as the previous assessment (p <0.001, l.s.d

= 17.33, **Error! Reference source not found.**). Prototype 3 produced the tallest plants (170.4 cm), with the shortest plants growing in the coir-free blend (133.8 cm). The nursery standard measured 165.6 cm.

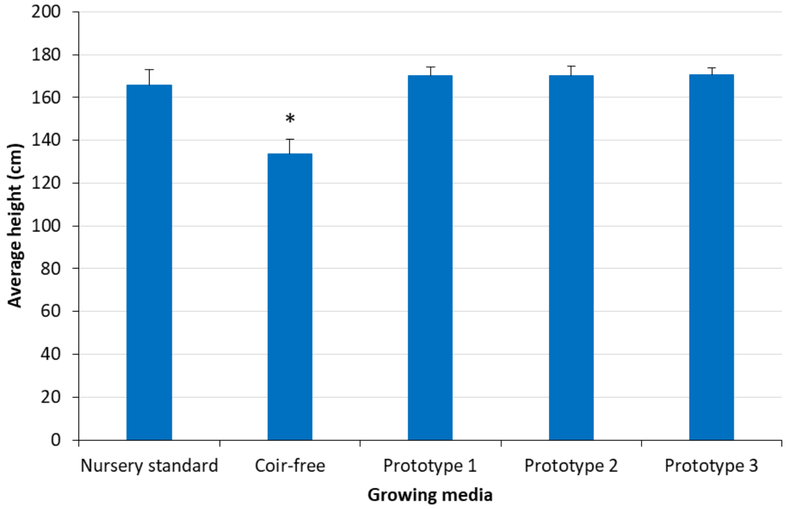


Figure 15. Average plant height for Glen Ample grown in different growing media blends 30 weeks after transplant, week 51, 2017. Differences across treatments are statistically significant (p <0.001, l.s.d = 17.33). Error bars represent 1 standard error, with 4 degrees of freedom (d.f.). * = treatments are significantly different to the nursery standard.

The number of nodes per plant was significantly different between treatments at each assessment date (**Table 4**). At the final assessment 30 weeks after transplant, the greatest number of nodes were in the nursery standard (33) and the lowest number were in the coir-free blend (24). There were no significant differences between the nursery standard and the three prototypes. The number of nodes per cane is important as this indicates the number of fruiting lateral shoots that will be produced in the following year.

Table 4. Average number of nodes per cane at each assessment date, Glen Ample. Plants were topped prior to the 30WAT assessment. Figures in red are significantly different to the nursery standard.

	Average number of nodes per cane				**Height 30**	**Average distance**
Treatment	**6 WAT**	**12 WAT**	**18 WAT**	**30 WAT**	**WAT (cm)**	**between nodes (cm)**
Nursery standard	13	21	35	33	165.6	5.02
Coir-free	11	18	28	24	133.8	5.58
Prototype 1	12	20	35	31	170.1	5.49
Prototype 2	13	21	35	32	170.0	5.31
Prototype 3	12	21	34	32	170.4	5.33
F. pr	0.004	0.042	0.002	0.003	<0.001	N/A
l.s.d	1.3	2.1	3.8	4.5	17.33	N/A

*WAT = weeks after transplant

Results

Maravilla

Pre-transplant

In week 21, there were no significant differences between treatments for the number of leaves per plant; all plants had three true leaves. Quality of the plants was significantly different (p <0.001, l.s.d = 0.2844), although all treatments scored greater than 3.0, the baseline for acceptable quality. Plants grown in the coir standard received the highest quality score (4.94), and those grown in the coir-free blend received the lowest quality score (3.60). The nursery standard scored significantly higher than all of the experimental treatments, although there was no significant difference between the three prototype blends; they were all very similar. The trends seen in the quality of the plants were reflected in the height, with significant differences between treatments (p <0.001, l.s.d = 0.996). The largest plants were produced in the nursery standard (11.9 cm), this was significantly greater than all of the experimental treatments. The shortest plants were produced in the coir-free blend (6.51 cm); this was significantly shorter compared with all other treatments. There were also significant differences between the prototypes, with prototype 2 taller than prototype 3.

There were significant differences between treatments for root development (p <0.001, l.s.d = 0.3725, **Figure 16**). The nursery standard was significantly better than all experimental treatments, scoring 3.84, with a well-developed root system. Prototype 3 scored the lowest (2.56), and this was significantly different to prototypes 1 and 2.

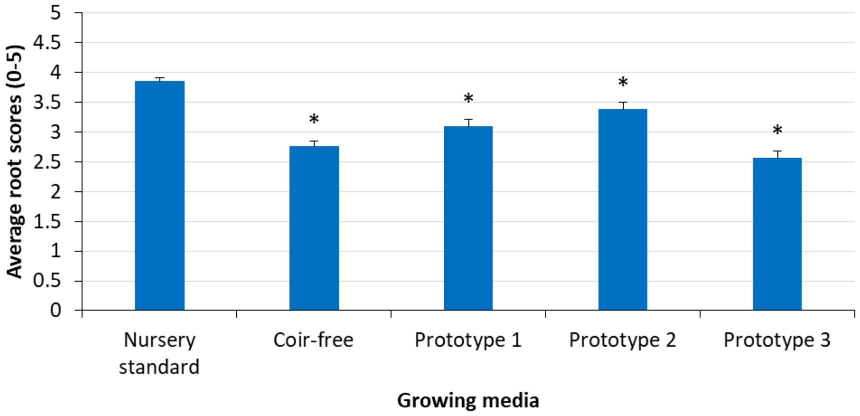


Figure 16. Average root scores for Maravilla grown in different growing media blends at transplant, week 21, 2017. Differences across treatments are statistically significant (p <0.001, l.s.d = 0.3725). Error bars represent 1 standard error, with 4 degrees of freedom (d.f.). * = treatments are significantly different to the nursery standard.

Post-transplant

There were no significant differences between any of the treatments at any of the assessment dates for plant quality. At the six and 12 week assessments, all treatments scored 4.0. At the 18 week assessment, the nursery standard, prototype 2 and prototype 3 all scored 5.0, and prototype 1 and the coir-free blend scored 4.88. All plants had grown well, there were no signs of any nutrient deficiencies and the foliage was healthy and green.

The height of the plants within each treatment was significantly different at the first assessment date (p <0.001, l.s.d = 5.464). Six weeks after transplant, the nursery standard was significantly taller than all experimental treatments (55.5 cm), and the coir-free plants were the shortest (42.12 cm). There were no significant differences between the three prototypes. Differences in height were not significant 12 weeks after transplant, although the nursery standard plants were still the tallest (104.4 cm) and the coir-free blend plants were the shortest (92.4 cm). At the third assessment however, 18 weeks after transplant, things had changed, and the prototypes had overtaken the nursery standard (**Figure 17**). The plants in prototype 2 were now the tallest (167.6 cm); this was significantly greater than the nursery standard (152.0 cm; p =0.001, l.s.d = 12.70). The coir-free plants were still the shortest (140.4 cm) but this was no longer significantly different to the nursery standard. At the final assessment 30 weeks after transplant, although the plants had been topped a few weeks previously, the trend was similar to the 18 week assessment, with the tallest plants in prototype 2 (162.8 cm) and the shortest plants in the coir-free blend (140.8 cm). The nursery standard measured 145.6 cm and was significantly shorter than prototype 2. The three prototypes were not significantly different to each other, and all were taller than the nursery standard and the coir-free blend.

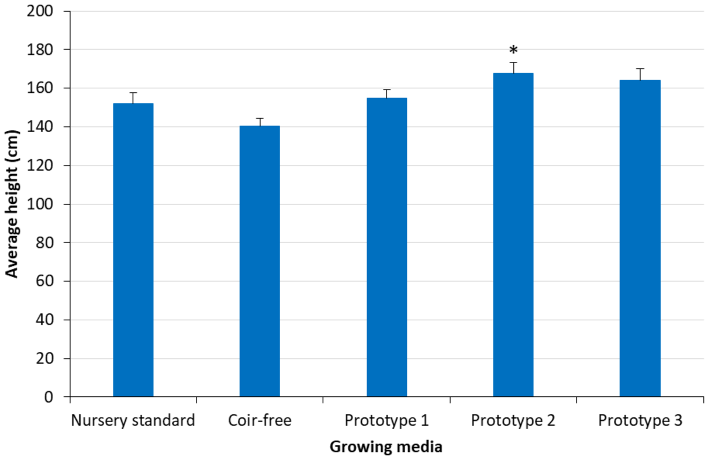


Figure 17. Average plant height for Maravilla grown in different growing media blends 18 weeks after transplant, week 39, 2017. Differences across treatments are statistically significant (p =0.001, l.s.d = 12.70). Error bars represent 1 standard error, with 4 degrees of freedom (d.f.). * = treatments are significantly different to the nursery standard.

The number of nodes per cane was not significantly different between treatments at the first assessment, six weeks after transplant. However differences between treatments were significant at the 12 week assessment (p =0.027, l.s.d = 1.966; **Table 5**), with prototype 3 producing more nodes (20) compared to 19 for the nursery standard. The smallest number of nodes were produced in the coir-free blend (16) which was significantly different to the nursery standard. A similar trend was seen 18 weeks after transplant (p =0.009, l.s.d = 2.627) with significantly less nodes in the coir-free blend and prototype 1 compared to the nursery standard. The length of cane with bud break was measured at the final assessment 30 weeks after transplant, and this was similar to node development, with the greatest length of cane showing bud break in prototype 3 (69 cm) compared to 62 cm in the nursery standard. The coir-free blend had the shortest length of cane with bud break, measuring 57 cm. However, none of the treatments were significantly different to the nursery standard. Only the coir-free blend was significantly shorter than prototypes 1 and 3.

Table 5. Average number of nodes per cane at each assessment date, Maravilla. Average cane length with bud break was assessed 30WAT. Figures in red are significantly different to the nursery standard.

	Average no. of nodes per cane			**Height 18 WAT (cm)**	**Av. distance between nodes 18 WAT(cm)**	**Av. length with bud break 30 WAT (cm)**
Treatment	**6 WAT**	**12 WAT**	**18 WAT**			
Nursery standard	13	19	34	152.0	4.47	62
Coir-free	11	16	30	140.4	4.68	57
Prototype 1	11	18	31	155.0	5.00	65
Prototype 2	11	18	35	167.6	4.79	63
Prototype 3	11	20	33	164.0	4.97	69
F. pr	0.070	0.027	0.009	0.001	N/A	0.026

l.s.d	1.3	2.0	2.6	12.70	N/A	7.0

*WAT = weeks after transplant

Discussion

Generally, the plants produced in the experimental treatments for both the Glen Ample and Maravilla were comparable to the nursery standard. With the Glen Ample, although the prototype plants were shorter than the nursery standard at transplanting, by the end of 2017, they had overtaken and were taller than the nursery standard. When the Glen Ample were grown on in 2018, the only real difference was with primocane development and yield in the coir-free blend, due to the fact that these plants were smaller to start with. There was very little difference between the prototypes and the nursery standard in 2018.

The Maravilla were very similar to the Glen Ample pre-transplant, with larger plants in the nursery standard. By the end of the trial, all of the prototypes were taller than the nursery standard, prototype 2 significantly so. The coir-free plants remained the shortest throughout the trial, although by the end, they were not significantly shorter than the nursery standard. Although the coir-free blend did not perform as well as the prototype blends, it is likely that refining the irrigation and nutrition would improve the performance of this blend.

Soft fruit propagation – strawberries

Methods

Trials were carried out at EU Plants Ltd (Finchampstead, RG40 3TS) using propagated strawberry material of Elsanta, from July 2017 until June 2018. Five growing media treatments were used and these were replicated eight times, to give a total of 40 plots, which were set out in a randomised trial design (**Appendix 2**). No base dressing was added to any of the growing media used in this trial, as it would be supplied in the irrigation water.

The strawberries were planted into 84-cell trays for the initial propagation stage in week 28, 2017, with one tray per plot, giving a total of 672 plants per treatment. Each tray was hand-filled with the relevant growing media, labelled and wet-up by sprinkler before planting. The plant material was hand stuck by nursery staff to ensure that all trays were even and to a commercial standard. The trays were placed alongside the nursery's commercial crop, on plastic pallets to prevent them from touching the floor, and the plants were grown on within an uncovered polytunnel, with overhead irrigation.

In week 32 2017, the trial was assessed for the number of leaves per plant, plant height, plant quality (scale of 0-5) and root development (scale of 0-5) for four plants per plot. For scoring criteria see **Appendix 2**. A sub-sample of the strawberry plants were then transplanted into 18-cell trays for growing on, using the same media that they had been propagated in (**Figure 18**). Each plot contained 18 plants within one tray, with each treatment replicated eight times, resulting in 144 plants per treatment. The trays were set-down on mypex in a fully randomised trial design alongside the nursery's commercial crop, in an uncovered polytunnel, and irrigated overhead. Plants were treated for pest and disease as appropriate, following the standard practice of the nursery.

Figure 18. Trays of strawberries ready for transplanting (left) and plants transplanted into larger trays (right), week 32 2017.

The trial was assessed at five and 10 weeks after transplant, for height, quality (scale of 0-5) and root development (scale of 0-5; **Appendix 2**) on eight plants per plot. In week 51 2017, a sub-sample of plants were assessed for crown size, and all plants were then placed into cold storage for the winter. The plants were grown-on as an observational trial in 2018 at H Goodall and Son (Lymington, SO41 5SH) from March to June 2018. All plants were grown in coir-filled bags.

Results

Pre-transplant

In week 32, there were very few differences between treatments. The plants had all grown well, the foliage was healthy and green, and each treatment had produced the same number of leaves. There were no differences in crop quality scores, with all treatments scoring 3.0, which is the minimum score required to be of acceptable quality. There was no significant difference in the height of the plants either, with the tallest produced in prototype 3 (16.3 cm), those grown in the nursery standard measuring 16.0 cm, and the shortest produced in the coir-free blend (15.1 cm). The only significant difference was in visible root development (p =0.037, l.s.d = 0.3566). Prototype 1 scored significantly lower than all other treatments, with an average score of 3.47 (rooting in up to 50% of the cell). The highest level of rooting was seen in the coir-free treatment, with a score of 4.0 (rooting in up to 85% of the cell), and plants grown in the nursery standard scored 3.8.

Post-transplant

When the trial was assessed at five and 10 weeks after transplant, there were very few differences between treatments. The height of the plants was not significant at either of the assessment dates. At the second assessment 10 weeks after transplant, the tallest plants were produced in the nursery standard (23.8 cm), and the shortest plants were produced in prototype 1 (21.4 cm). The same trend was seen in the first assessment five weeks after transplant. The quality of the plants was not significantly different either. At the final assessment, all plants scored 4.0, they had all grown well with healthy foliage which was dark green in colour.

There was a significant difference in root development at the first assessment five weeks after transplant (p =0.007, l.s.d = 0.1946). Prototype 1 scored 4.39 and was significantly lower than the coir-free blend, prototype 2 and prototype 3, which scored 4.73, 4.66 and 4.70 respectively. However, it was not significantly poorer than the coir standard, which scored 4.55. At the final assessment, root development had improved, and there were no significant differences between treatments. **Figure 19** shows root and foliage quality in the nursery standard, the coir-free blend and prototype 3.

Figure 19. Strawberry plants grown in the nursery standard (left), the coir-free blend (middle) and prototype 3 (right), week 42 2017.

Crown size

Crown size was measured on a sub-sample of plants in week 51 2017, just before the plants went into cold storage. There were no significant differences between treatments (p =0.070, **Table 6**). The largest crown size was recorded in the nursery standard (21.2 mm), and the smallest crown size was recorded in prototype 2 (17.93 mm).

Table 6. Crown size measured on a sub-sample of plants in week 51 2017.

Treatment	**Crown size (mm)**
Nursery standard	21.20
Coir-free	18.54
Prototype 1	19.64
Prototype 2	17.93
Prototype 3	19.64
l.s.d = 2.323	
F pr. = 0.070	

Discussion

Overall, in the strawberry propagation trial, the experimental blends were comparable with the nursery standard coir. Occasionally, prototype 1 scored slightly lower, although it did perform slightly better in the early stages of the trial, prior to transplant. Prototype 3 produced visibly better plants both pre- and post-transplant. Crown size was not significantly different, and when the plants were grown on in 2018 in coir bags, all treatments did well, there were no problems with plant or fruit quality.

Top fruit

Methods

Trials were carried out at Frank P Matthews (Tenbury Wells, WR15 8TH) on bare root trees of apple (Christmas Pippin) and cherry (Summersun) from week 12, 2017 until week 19, 2018. In each trial, four growing media treatments were used, treatments were replicated 18 times and plots were set out in a randomised trial design (**Appendix 3**).

Bare root trees were potted into 12 L pots (2 plants per plot) filled with the relevant growing media, and grown outdoors on gravel beds in separate areas of the nursery, as per commercial practice. Irrigation was delivered via drippers, one per pot. The trees were monitored regularly by nursery staff for any issues, such as different irrigation needs. Initially the prototypes required extra hand watering to ensure the trees were sufficiently watered in. Once this had occurred, no additional watering was necessary. Trees were assessed every four weeks until May 2017, every eight weeks during the growing season of 2017 and before sale in 2018 (**Table 7**). One tree per plot was assessed for girth (at 10 cm above the graft union), branch extension (cm) and number of branches over 10 cm at each assessment after planting. Additional assessments of flowering stage, leaf surface area (of fifth newest leaf), and final quality and root scores were also performed during the trial. Both apple and cherry trees were pruned on 04 July 2017, which meant that branch extensions could not be measured at the 16 week assessment. New side branch growth was measured in the subsequent assessments. At the final assessment at 59 weeks after planting on 11 May 2018, the tree quality and root development scores were recorded. For assessment criteria see **Appendix 3**.

Table 7. Assessment dates and measurements taken.

Assessment (weeks after planting)	**Date**	**Measurements**
Planting	23/03/2017 (week 12)	Girth, growing media analysis
4 Weeks	12/04/2017 (week 16)	Girth, branch extension, flowering stage
8 Weeks	17/05/2017 (week 20)	Girth, branch extension, number of branches
16 Weeks	11/07/2017 (week 28)	Girth, number of branches, leaf surface area
24 Weeks	07/09/2017 (week 36)	Girth, branch extension, number of branches, leaf surface area, leaf nutrient analysis
32 Weeks	01/11/2017 (week 44)	Girth, branch extension, number of branches, growing media analysis
59 Weeks	11/05/2018 (week 19)	Final assessments: quality and root scores, girth, number of branches

Results

Cherry

Throughout the trial, there were no significant differences in the change of the tree girth in response to growing media type. Root and quality scores were measured at the end of the trial and there were no significant differences for either at the final assessment. **Figure 20** shows the final trees in each treatment, all of the trees were of excellent quality regardless of the growing media treatment they were produced in, with all treatments scoring 4 or above. The roots of all of the trees were also very comparable, with all treatments scoring 3 (51-75% pot fill) or above.

Figure 20. Cherry trees at the final assessment date, week 19 2018. L:R - Prototype 3, Prototype 2, Prototype 1, Nursery standard.

There were slight differences in the mean branch regrowth after pruning at the 59 week assessment, with prototype 1 having the lowest regrowth of all of the treatments. However, the regrowth was variable within the treatments and the differences seen were not significantly different for any of the treatments in the trial.

Apple

Throughout the trial, although the nursery standard and prototype 3 showed the smallest increase in tree girth, differences between treatments were not significant. Root and quality scores were measured at the end of the trial and there were no significant differences for either at the final assessment. **Figure 21** shows the final trees in each treatment, all of the trees were of excellent quality regardless of the growing media treatment they were produced in, with all treatments scoring 4 or above. The roots of all of the trees were comparable, with all treatments scoring 3 (51-75% pot fill) or above.

Figure 21. Apple trees at final assessment date, week 19 2018. L:R - Prototype 3, Prototype 2, Prototype 1, Nursery standard.

Leaf area was measured on the youngest leaves from two branches per tree. There was no significant difference in the leaf area for any of the treatments. There was a significant difference in the mean branch regrowth after pruning at the end of the trial (p <0.001, l.s.d = 19.16). Prototypes 1 and 2 had the greatest regrowth of the treatments (22.0 cm and 21.9 cm respectively) and produced more regrowth compared to prototype 3 and the nursery standard (19.9 cm and 17.5 cm respectively).

Discussion

For both apple and cherry performance, there were almost no significant differences in any of the variables measured in the propagated trees. The cherry trees in particular were uniform across all of the treatments. The quality of the final trees was very high and all of the treatments had produced good root growth, all filling up to 75% of visible pot volume.

There were differences in the regrowth of the apple trees after pruning, with prototypes 1 and 2 having the largest regrowth after 16 weeks. The increase in the girth of the apple trees in the growing media treatments followed a similar trend, with both prototypes 1 and 2 having the largest increase in tree girth. These differences did not affect the overall quality scores at the end of the trial and although there were very minor differences in the root scores by growing media type, these were not significant.

Overall, all of the blends produced trees of marketable quality in both the cherries and the apples. The prototypes performed as well as the nursery's peat-free standard, indicating that these are as good as commercially available peat-free growing media.

Hardy Nursery Stock

Methods

Trials were carried out on potted liner material of *Choisya ternata* 'Goldfingers', *Hebe* 'Heartbreaker' and *Salvia* 'Hot Lips' at Lowaters Nurseries Ltd (Southampton, SO31 9HH) from week 11, 2017 to week 17, 2018. *Choisya* and *Salvia* were potted in week 11, and *Hebe* were potted in week 22. In each trial, four growing media treatments were used, treatments were replicated eight times and plots were set out in a randomised trial design (**Appendix 4**).

Liners were potted into black 2 L pots (5 plants per plot) filled with the relevant growing media, and grown on the floor on mypex under glass (*Choisya* and *Hebe*) and polythene (*Salvia*) as per commercial practice. Irrigation was delivered via sub-irrigation. As *Salvia* is a quick-growing crop, this trial was only assessed twice, at seven and 11 weeks after potting. The *Choisya* and *Hebe* were grown on until week 17, 2018 (25 April), and were assessed at 7, 14, 21, 35 and 58 weeks after potting (*Choisya*) and 7, 14, 21, 27 and 47 weeks after potting (*Hebe*). At each assessment date, plots were assessed for plant quality (5 plants per plot, scale 0-5), plant height (3 plants per plot) and root development (3 plants per plot, scale 0-4). Both the *Choisya* and *Hebe* were trimmed in week 41, 2017, as per commercial practice, so that re-growth in the following spring could be assessed. For scoring criteria see **Appendix 4**.

Results

Choisya

At the end of the *Choisya* trial there was little difference between treatments, and all three prototypes produced plants that were of marketable quality. There had been some quality differences during the summer of 2017, with some leaf scorch in prototypes 1 and 2, likely related to heat stress, but the plants grew away from this apparent growth check and at the final assessment in week 17, 2018, there were no significant differences between treatments (**Figure 22**).

Figure 22. *Choisya* grown in different growing media blends at the final assessment, 58 weeks after potting, week 17, 2018. L-R: nursery standard, prototype 1, prototype 2, prototype 3.

At the fourth assessment 28 weeks after potting (week 39), just prior to the plants being trimmed, the tallest plants were in the nursery standard (57.8 cm) and the shortest plants were in prototype 1 (49.4 cm). The plants were then trimmed so that all plants across the trial were of an even height, and they were left to overwinter and re-grow in spring 2018. At the final assessment 58 weeks after potting (week 17, 2018), the tallest plants remained in the nursery standard (15.6 cm) and the shortest plants were in prototype 3 (14.6 cm). Throughout the trial, there were no significant differences in plant height between any of the treatments at any of the assessment dates.

The roots of the *Choisya* plants were visibly slow to develop, and by the first assessment, seven weeks after potting, they were only just reaching the edges of the pot, and therefore no differences could be seen between treatments. Root development differences became apparent later on in the trial, with poorer root development in prototypes 1 and 3, and this remained the case until the end of the trial. At the final assessment in week 17, 2018 (58 weeks after potting), the root development in the nursery standard was significantly better compared with prototypes 1 and 3 (p <0.001, l.s.d = 0.4256, **Figure 23**). There had been some root death over winter in all treatments followed by new season growth for all treatments. Root scores for the nursery standard averaged 2.667 (rooting in up to 50% of the pot), with the lowest score being 1.75 for prototypes 1 and 3 (rooting in up to 25% of the pot).

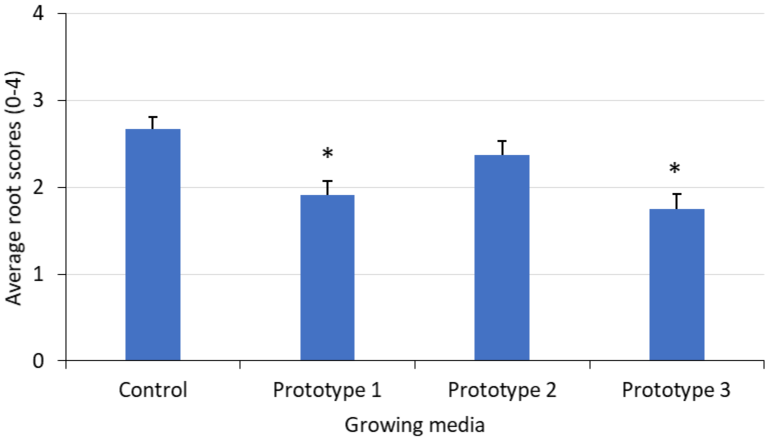


Figure 23. Average root scores for *Choisya* grown in different growing media blends 58 weeks after potting, week 17, 2018. Differences across treatments are statistically significant (p <0.001, l.s.d = 0.4256). Error bars represent 1 standard error, with 3 degrees of freedom (d.f.). * = treatments are significantly different to the nursery standard.

Hebe

There were no significant differences in quality between any of the treatments at the first four assessments on *Hebe*. There was a small amount of leaf scorch noted on some plants, but this did not appear to be linked to treatment, and the plants recovered from an observed growth check. It was only at the final assessment, 47 weeks after potting, that differences between treatments were statistically significant (p =0.008, l.s.d = 0.5574), with the nursery standard scoring higher (4.175) than all of the prototype treatments. The lowest score was seen in prototype 3 (3.25), which scored above the baseline of 3.0, meaning the plants were still commercially acceptable. Plants were of a good quality, with plenty of new growth coming through (**Figure 24**). The plants had also started to "colour up" over winter, and there were no differences in colour or time to colour.

Figure 24. *Hebe* grown in different growing media blends at the final assessment, 47 weeks after potting, week 17, 2018. L-R: nursery standard, prototype 1, prototype 2, prototype 3.

Throughout the trial, there were no significant differences in plant height between any of the treatments at any of the assessment dates. At the second assessment 14 weeks after potting (week 36), just prior to the plants being trimmed, the tallest plants were in prototype 2 (24.8 cm) and the shortest plants were in both the nursery standard and prototype 1 (23.6 cm). The plants were then trimmed so that all plants across the trial were of an even height, and they were left to overwinter and re-grow in spring 2018. At the final assessment 47 weeks after potting (week 17, 2018), there was very little difference between treatments, although the plants in the nursery standard growing media were slightly taller.

There were no significant differences between treatments for root development at the first two assessments, seven and 14 weeks after potting. At the third assessment 21 weeks after potting, differences between treatments were significant (p =0.050, l.s.d = 0.3275), with greater root development in prototype 2 (3.167) compared to the nursery standard (2.708). The nursery standard was not significantly different to prototype 1 or 3. At the final assessment 47 weeks after potting, root development in prototype 2 was significantly better than all other treatments (p <0.001, l.s.d = 0.4014, **Figure 25**), with the lowest root score in the nursery standard (2.375).

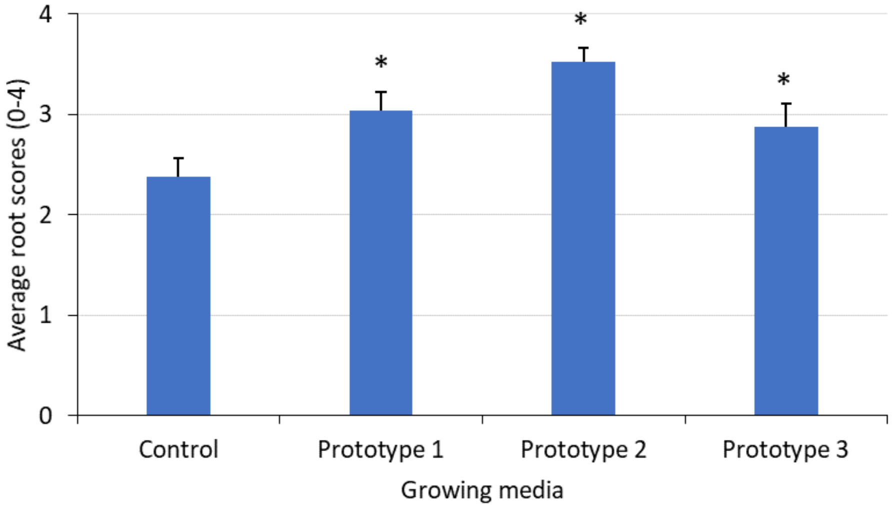


Figure 25. Average root scores for *Hebe* grown in different growing media blends 47 weeks after potting, week 17, 2018. Differences across treatments are statistically significant (p <0.001, l.s.d = 0.4014). Error bars represent 1 standard error, with 3 degrees of freedom (d.f.). * = treatments are significantly different to the nursery standard.

Salvia

There were no significant differences in quality between treatments at the first assessment seven weeks after potting. The plants had grown very quickly, accumulating biomass for each treatment, and all plants were developing flowers. At the final assessment 11 weeks after potting, prototype 1 scored significantly lower than all other treatments (p =0.013, l.s.d = 0.2206, **Figure 26**). However, with a score of 4.65 the plants were still of a very good quality and were commercially acceptable.

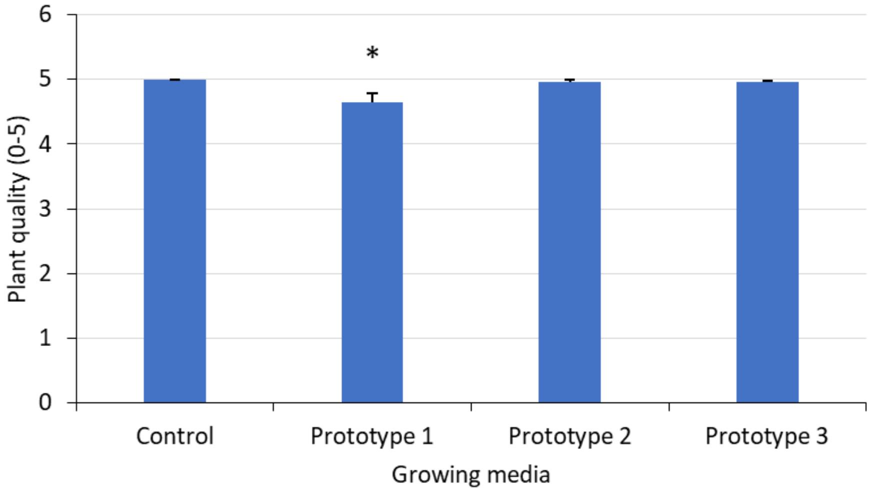


Figure 26. Average *Salvia* quality (scored 0-5) in different growing media blends 11 weeks after potting, week 22, 2017. Differences across treatments are statistically significant (p =0.013, l.s.d = 0.2206). Error bars represent 1 standard error, with 3 degrees of freedom (d.f.). * = treatments are significantly different to the nursery standard.

There was a significant difference in height between treatments seven weeks after potting (p =0.001, l.s.d = 2.952). The tallest plants were in the nursery standard (62.8 cm), and this was significantly taller compared with prototype 1 (56.8 cm) and prototype 3 (59.5 cm); prototype 2 was similar in height (62.3 cm) to the nursery standard. The *Salvia* were then trimmed, and as a result there were no differences in height between treatments at the final assessment, 11 weeks after potting.

At the first assessment there were no significant differences in root development between treatments. The plants were rooting out well and there was plenty of new white root coming through (**Figure 27**). At the final assessment 11 weeks after potting, the best root development was in prototype 3, closely followed by the nursery standard and prototype 2 (**Figure *28***). The root development in prototype 1 was significantly less compared with the remaining blends (p =0.032, l.s.d = 0.3887), but was still of acceptable growth score quality (3.46).

Figure 27. *Salvia* root development in different growing media blends seven weeks after potting, week 18, 2017. L-R: nursery standard, prototype 1, prototype 2, prototype 3.

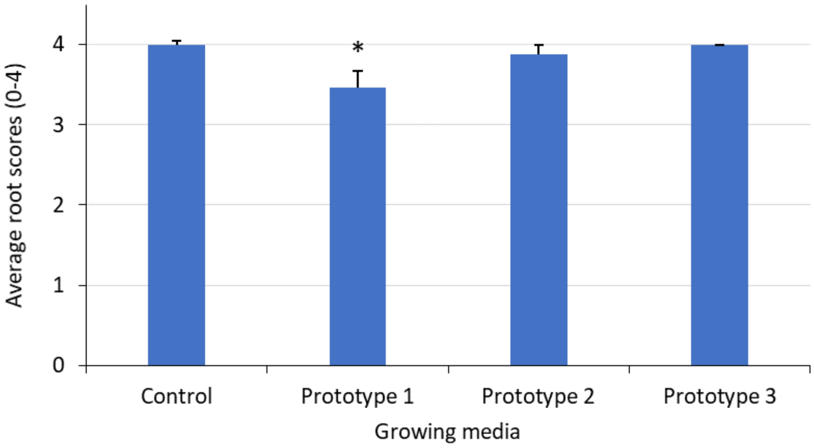


Figure 28. Average root scores for *Salvia* grown in different growing media blends 11 weeks after potting, week 22, 2017. Differences across treatments are statistically significant (p =0.032, l.s.d = 0.3887). Error bars represent 1 standard error, with 3 degrees of freedom (d.f.). * = treatments are significantly different to the nursery standard.

Discussion

Overall, all three of the prototype blends performed well in hardy nursery stock production. None of the blends failed, and all plants were of a good height and quality. There was a bit more of a difference in root development, particularly in the *Hebe* trial, where there appeared to be insufficient drainage to support strong overwinter plant performance. Of the three prototypes, prototype 2 emerged as the strongest performing blend, and for the majority of the assessment criteria across the three species, was as good as, or better, than the nursery standard.

Conclusions

Overall, the prototype blends performed well on long-term overwintering crops on commercial nurseries, and generally the plants were as good as the nursery standard. There were some very slight differences in performance between the prototypes in the HNS trial, with prototype 2 working particularly well. In the top fruit trial there were no noticeable differences between prototypes. For soft and cane fruit, which were grown on a system optimised for coir, the coir-free blend did not perform as well as the nursery standard, although there was little difference between the three peat-free prototypes, and all of these performed well when grown on to yield in 2018. The results shown in the experimental trials in 2016 were reflected quite nicely in the grower trials in 2017 and 2018, which shows that the modelling approach taken for the first set of prototypes, to try and emulate peat, was a useful place to start. It has been shown that by taking a set of materials with a certain set of physical properties that are similar to those of peat, it is possible to grow plants in a range of crop sectors, and produce high quality plants.

2018 Second generation prototype blend testing – “main-campaign” grower hosted trials

During 2018, trials were carried out on four grower sites, with most of the nurseries hosting more than one trial (**Table 8**). Five experimental prototype blends were tested against the nurseries standard product, resulting in six growing media treatments per trial. Four of these blends were ‘2nd generation’ peat-free prototype blends (Prototypes 4-7) which were originally tested at ADAS Boxworth in 2017. These blends were designed to explore a wider area of physical properties, and were therefore recognised as more ‘extreme’ blends. Of these four blends, one of these was also coir-free, as well as peat-free. In addition, one ‘1st generation’ prototype blend (Prototypes 1-3) was tested on each nursery, in order to gather year-on-year data and see whether the results generated in the first year of testing would be replicated. For each sector, the best performing 1st generation prototype blend was selected to carry forward, therefore the blends used on the individual nurseries were likely to be different. It is important to note that the coir, bark and woodfibre used in the 2nd generation blends is different to the 1st generation blends. The green compost remains the same. Prior to the trials commencing, the blends were analysed for their chemical properties, and then fertilisers were added as appropriate, to try to ensure that the blends were balanced nutritionally at the beginning of each trial. Nutrition levels for each crop were agreed with the host grower prior to trial commencement. This was to ensure that observed differences were not because of nutrient availability but because of growing media blend physical properties. The prototype blends plus the standard nursery blends were also tested for physical properties. All data were analysed using Analysis of Variance (ANOVA) with use of Duncan’s multiple range test to separate treatments. The test was used with a 95% confidence level.

Table 8. Grower hosted trials in 2018.

Host	Trial	Duration
Darby Nursery Stock*	HNS Liners and Finals	Potted week 20, 2018. Lavender finals completed week 40. All other species overwintering into 2019.
Delfland Nurseries	Veg prop	Sown week 36 and 38, completed week 41.
EU Plants*	Raspberry prop	Set-up week 17. Overwintering into 2019.
EU Plants*	Strawberry prop	Set-up week 28. Overwintering into 2019.
Newey Roundstone	Bedding	Summer: transplanted week 19 and 21, completed week 24. Autumn: transplanted week 39, completed week 44.

*Note that overwintering trials have not been included in this report

Vegetable propagation

Methods

Trials were carried out on Chinese cabbage ‘Kaboko’ and Spring cabbage ‘Caraflex’ at Delfland Nurseries Limited (Cambridgeshire, PE15 0TU) from 31 August until 11 October 2018. In each trial, six growing media treatments were used (**Appendix 5**), with prototype 1 selected as the 1st generation blend.

Seeds were sown into 345-cell trays in week 36 (Spring cabbage) and week 38 (Chinese cabbage). The trays were filled with the relevant growing media by hand, covered with a fine layer of vermiculite, covered with white plastic, and left in the germination room for two days. The trays were then set out on the floor under glass in a randomised trial design (**Appendix 5**), and were placed on upturned pots as per commercial practice, to allow for aeration and air pruning of the root system for growth control (**Figure 29**). The trial was watered overhead by hand, as and when required.

Figure 29. Spring and Chinese cabbage set out on concrete under glass at Delfland Nursery, week 38.

Germination was monitored by nursery operatives who informed ADAS staff when the seeds had germinated. The trials were assessed in week 41 for percentage germination of each tray, plant quality (plot overall, scale of 1-3), plant height (10 plants per plot), fresh and dry weight (10 plants per plot), and root quality (10 plants per plot, scale of 0-4). For scoring criteria see **Appendix 5**.

Results

Chinese cabbage

Germination (>95% emergence) occurred within three days across all treatments. There was, however, a significant difference in percentage germination (p =0.009, l.s.d = 1.76), with prototype 7 which was significantly lower compared with the nursery standard (96.2%), but remained an acceptable germination figure. None of the other treatments were significantly different to the nursery standard (**Table 9**).

Table 9. Percentage germination for Chinese cabbage sown week 38, 2018.

Treatment	**% germination**
Nursery standard	99.9
Prototype 1 (1st Gen)	99.5
Prototype 4 (2nd Gen)	98.5
Prototype 5 (2nd Gen)	98.3
Prototype 6 (2nd Gen)	98.6
Prototype 7 (2nd Gen)	96.2*

l.s.d = 1.76
F pr. = 0.009
* = significantly different to the nursery standard

For plant quality, the nursery standard and prototype 1 both scored 3.0, the highest quality score. These plants were well developed, with full leaves, and good foliage colour (**Figure 30**). There was some damage from flea beetle but this occurred across all treatments. All other treatments scored significantly lower than the nursery standard and prototype 1 (p <0.001, l.s.d = 0.31) with the lowest score of 2.0 given to prototypes 4, 5 and 7. However, although these treatments received a lower score, they were of marketable quality, with the threshold for scoring being 2.0. The plants were just a bit smaller and the leaves were not as full as the plants in the nursery standard and prototype 1.

Figure 30. Chinese cabbage grown in the nursery standard (left), and prototype 1 (right), week 41 2018.

As with plant quality, there was no significant difference between the nursery standard and prototype 1 for plant height. The nursery standard produced the largest plants (84.3 mm), and the plants grown in prototype 1 measured 80.03 mm. All other treatments were significantly shorter than the nursery standard and prototype 1 (p <0.001, l.s.d = 9.57, **Figure 31**). The shortest plants were grown in prototype 4 (35.0 mm), followed by prototype 7 (37.7 mm).

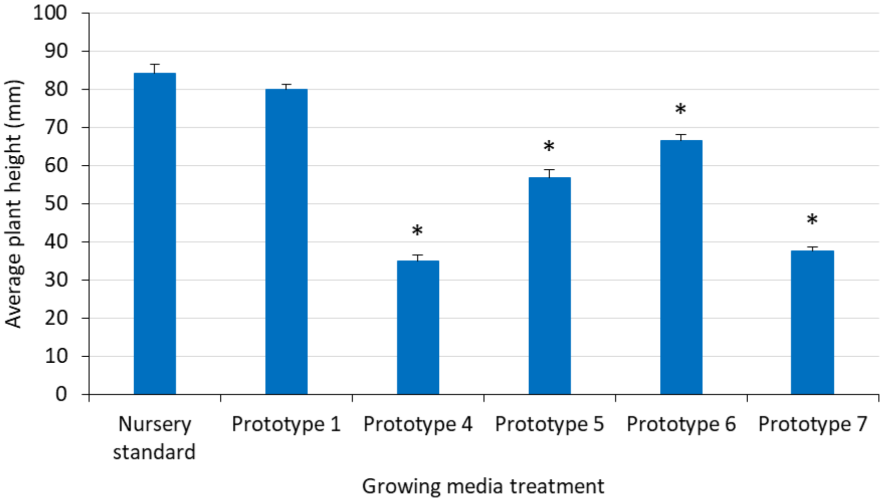


Figure 31. Average height (mm) of Chinese Cabbage plants grown in different growing media blends. Differences across treatments are statistically significant (p <.001, l.s.d = 9.57). Error bars represent 1 standard error, with 5 degrees of freedom (d.f.). * = treatments are significantly different to the nursery standard.

There was a significant difference between treatments for both the fresh and dry weight of individual plants (p <0.001 for both, l.s.d = 0.17 and 0.008 respectively), with the nursery standard producing plants with the greatest fresh weight (1.69 g). This was closely followed by prototype 1 (1.69 g), and the lightest plants were produced in prototype 7 (0.56 g, **Figure *32***). When it came to dry weight, the nursery standard and prototype 1 were not significantly different to each other (0.082 g and 0.075 g respectively), but they were significantly greater than the other four treatments. As expected, the lowest dry weight occurred in prototype 7 (0.035 g).

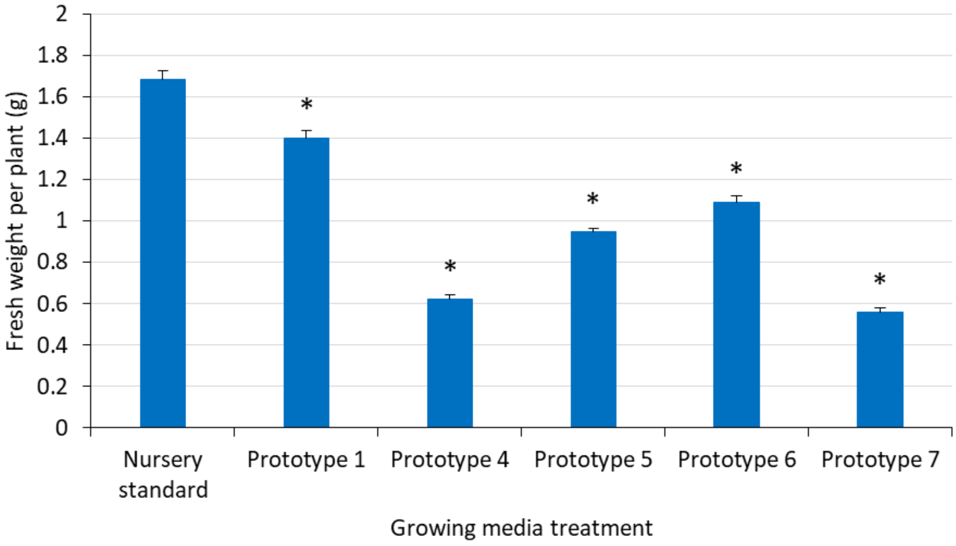


Figure 32. Average fresh weight (g) of Chinese Cabbage plants grown in different growing media blends. Differences across treatments are statistically significant (p <.001, l.s.d = 0.17). Error bars represent 1 standard error, with 5 degrees of freedom (d.f.). * = treatments are significantly different to the nursery standard.

In terms of root development, there were no significant differences between treatments. The highest root development score of 2.5 was given to the nursery standard, prototype 1 and prototype 5. The lowest root development score was given to prototype 7, which scored 2.0. However, plants in all treatments had produced plenty of healthy white root, which filled the entire plug volume.

Spring cabbage

Germination occurred one week after the seeds were sown, and there were no differences between treatments in terms of germination timing. There were also no significant differences between treatments for percentage germination, with the highest level of germination in the nursery standard (97.6%) and the lowest in prototype 5 (95.9%) (**Table 10**).

Table 10. Percentage germination for Spring cabbage sown week 36, 2018.

Treatment	**% germination**
Nursery standard	97.6
Prototype 1 (1st Gen)	96.5
Prototype 4 (2nd Gen)	97.2
Prototype 5 (2nd Gen)	95.9
Prototype 6 (2nd Gen)	96.7
Prototype 7 (2nd Gen)	97.0
l.s.d = 1.22 F pr. = 0.100	

For plant quality, the nursery standard, prototype 1 and prototype 6 all scored 3.0, the highest quality score. Similar to the Chinese cabbage, these plants were well developed, with full leaves, and good foliage colour (**Figure 33**). All other treatments scored significantly lower than the nursery standard, prototype 1 and prototype 6 (p <0.001, l.s.d = 0.39) with the lowest score of 2.0 given to prototype 4. However, although these treatments received a lower score, they were of marketable quality, the threshold being 2.0. The plants were just a bit smaller and the leaves were not as full as the plants in the nursery standard, prototype 1 and prototype 6.

Figure 33. Spring cabbage grown in the nursery standard (left), prototype 1 (middle), and prototype 6 (right), week 41 2018.

There was a significant difference between treatments for plant height (p <0.001, l.s.d = 9.29), with the nursery standard greater than all the other treatments (106.0 mm, **Figure *34***). This was followed by prototype 6 (90.47 mm) and prototype 1 (84.7 mm). The shortest plants were grown in prototype 4 (69.0 mm), and were significantly shorter than in all other treatments.

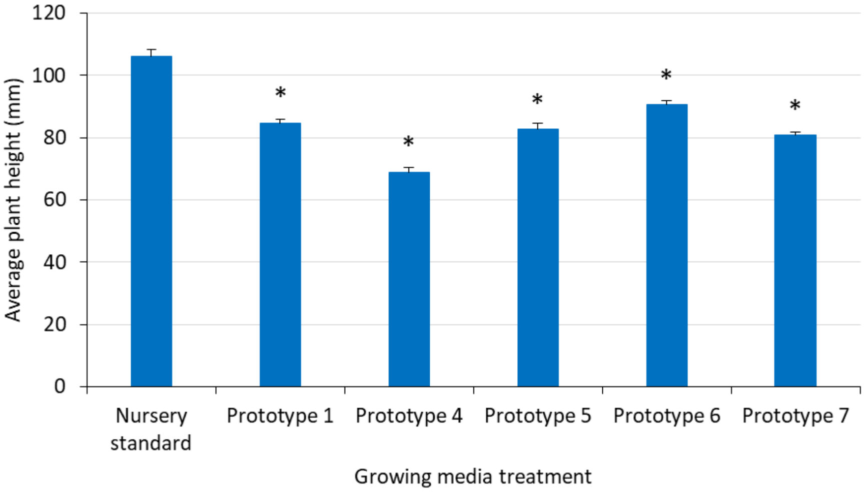


Figure 34. Average height (mm) of Spring Cabbage plants grown in different growing media blends. Differences across treatments are statistically significant (p <.001, l.s.d = 9.29). Error bars represent 1 standard error, with 5 degrees of freedom (d.f.). * = treatments are significantly different to the nursery standard.

There was a significant difference between treatments for both the fresh and dry weight of individual plants (p <0.001 for both, l.s.d = 0.078 and 0.012 respectively), with the nursery standard producing the largest plant fresh weight (0.85 g). This was closely followed by prototype 1 (0.65 g), and the plants with least biomass were produced in prototype 4 (0.52 g, **Figure 35**). The dry weight results followed the same pattern, with the nursery standard significantly greater than all other treatments (0.075 g), followed by prototype 1 and 6 which both weighed 0.058 g; the lowest average dry weight was found in prototype 7 (0.043 g).

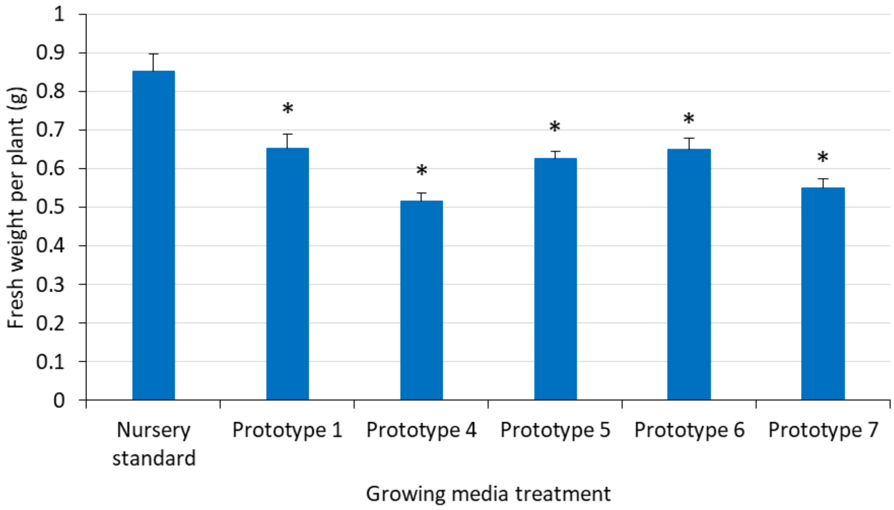


Figure 35. Average fresh weight (g) of Spring Cabbage plants grown in different growing media blends. Differences across treatments are statistically significant (p <.001, l.s.d = 0.078). Error bars represent 1 standard error, with 5 degrees of freedom (d.f.). * = treatments are significantly different to the nursery standard.

As with the Chinese cabbage, there were no significant differences between treatments for root development. The highest root development score of 2.3 was given to both prototype 1 and prototype 7. The lowest root development score was given to the nursery standard and prototype 6, which both scored 2.0. However, plants in all treatments had produced a healthy white root system which visually occupied the entire plug volume.

Discussion

Overall, there was some variability between treatments, but even in the lowest scoring treatments, the plants had grown quite well, and these prototypes would likely benefit from earlier feeding and different management (i.e. adjustments to watering). Prototype 1 proved to be the best performing prototype for both Chinese and Spring cabbage, and the plants were comparable to the nursery standard. The materials within this blend will retain moisture well, but also provide a suitable AFP, which will encourage root growth, and ensure that the blend does not become too wet. Prototype 6 also worked rather well in both trials.

Prototype 7 underperformed in both trials compared to the other prototypes, as did Prototype 4. The materials within this blend create a rather dense mix, which held on to the water too much, and therefore is not very well suited to vegetable propagation in modules.

Protected ornamentals – bedding

Methods

Trials were carried out at Newey Roundstone (Chichester, PO20 1LL) in summer and autumn 2018. The summer trial tested *Fuchsia* and *Pelargonium* 'Savannah' in 10.5 cm pots, and Petunia 'Frenzy' and *Pelargonium* 'Cabaret' in 10-cell packs. The autumn trial tested Pansy 'Inspire' in 10-cell packs. Each species was trialled separately using a statistically robust experimental design (**Appendix 6**).

A total of six growing media treatments were used in each trial (**Appendix 6**), with prototype 3 selected as the 1st generation blend. For the summer pot trials, each treatment was replicated three times, with five plants per plot, resulting in 15 plants per treatment, per species. For the summer pack trials, each treatment was replicated four times, with two 10-cell packs per plot, resulting in 80 plants per treatment, per species.

For the autumn pack trial, each treatment was replicated six times, with two 10-cell packs per plot, resulting in 120 plants per treatment.

For all trials, pots and packs were hand-filled with the relevant growing media and the plugs were transplanted by hand (week 19 – summer pots, week 21 – summer packs, week 39 – autumn packs). The summer trials were grown on under glass at Malands Nursery (PO20 7QX) and the autumn trial was grown on under glass at Newlands (PO20 1LL). Plants were watered and fed overhead as and when required.

The summer trials were assessed in week 24 (14 June 2018) and the autumn trial was assessed in week 44 (01 November 2018). Plants were assessed for height (four plants per plot – packs, all plants per plot – pots), plant quality (plot overall, scale 0-5), root development (4 plants per plot – packs, all plants per plot – pots, scale 0-4) and the number of plants per plot in flower. Fresh and dry weight was also completed on a sub-sample of plants (four plants per plot – packs, two plants per plot – pots). For scoring criteria see **Appendix 6.**

Results

Summer pot trials

Pelargonium

At the end of the trial, there were no significant differences between treatments for plant quality. A score of 3.0 or above is deemed commercially acceptable, and all treatments were above this. The plants were well-developed, covering the pots nicely, and the foliage was green and healthy. The highest scoring treatments were the nursery standard, and prototype 3, which both scored 5.0. Prototypes 4, 5 and 6 all scored 4.67, and the lowest score was given to prototype 7, which scored 4.33 and was still of marketable quality. There was also no significant difference in the number of plants in flower or in bud (**Table 11**).

Table 11. Number of Pelargonium plants per plot which were either in flower or in bud, week 24 2018. Differences between treatments are not statistically significant.

Treatment	No in flower (out of 5)	No. in bud (out of 5)
Nursery standard	0.33	4.00
Prototype 3 (1st Gen)	1.00	3.00
Prototype 4 (2nd Gen)	1.67	2.67
Prototype 5 (2nd Gen)	1.00	2.33
Prototype 6 (2nd Gen)	1.00	1.67
Prototype 7 (2nd Gen)	1.33	2.67
F pr.	0.791	0.557
l.s.d.	2.039	2.671

There were no significant differences between treatments for plant height. The tallest plants were grown in prototype 4, with an average height of 13.90 cm. This was closely followed by the nursery standard, with an average height of 13.87 cm. The shortest plants were grown in prototype 6, with an average height of 10.93 cm. Root development was also not significantly different. The greatest root development was seen in the nursery standard, with a score of 2.9. Prototype 7 received the lowest root score, with 2.1, and the remaining prototypes were all rather similar, scoring between 2.3 and 2.5.

The only significant differences in the pot *Pelargonium* trial were in the fresh and dry weights (p =0.005, l.s.d = 5.165 and p =0.054, l.s.d = 0.805 respectively). The greatest fresh weight was seen in prototype 3, with an average weight of 31.87 g per plant. The nursery standard plants weighed on average 29.78 g, and this was not significantly different to prototype 3, 4 or 6 (**Figure 36**). Both prototypes 5 and 7 were significantly lighter than the nursery standard, with prototype 7 weighing the least (20.08 g per plant). The trend for the dry weights was generally similar to the fresh weight.

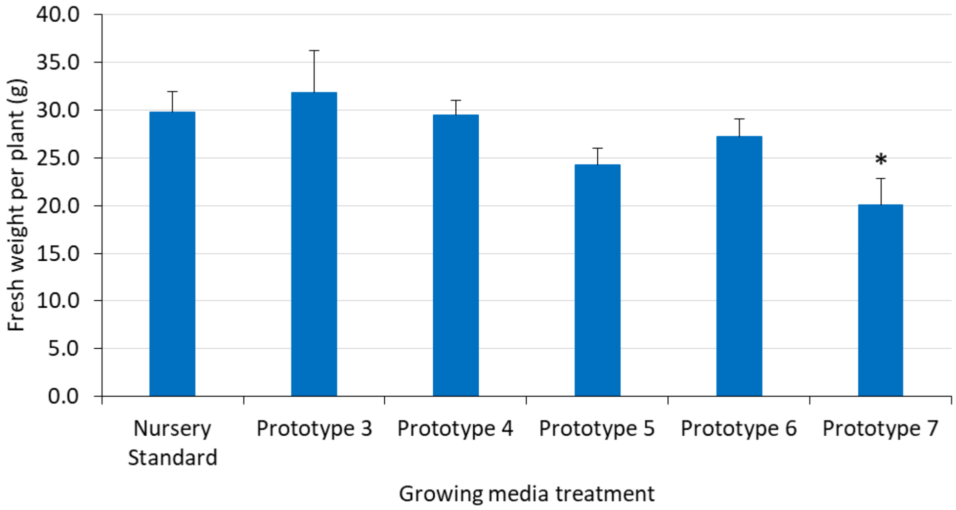


Figure 36. Average fresh weight of *Pelargonium* 'Savannah' grown in different growing media blends, week 24. Differences across treatments are statistically significant (p =0.005, l.s.d = 5.165). Error bars represent 1 standard error, with 5 degrees of freedom (d.f.). * = treatments are significantly different to the nursery standard.

Fuchsia

There were no significant differences between treatments for plant quality in week 24. The nursery standard, prototype 3 and prototype 5 all achieved the highest score of 5.0, and the lowest score of 4.3, which was still commercially acceptable, was given to prototypes 4 and 7. Plants were very well developed, covering the pot, with healthy green foliage. There were also no significant differences between treatments for the number of plants in flower or in bud (**Table 12**).

Table 12. Number of *Fuchsia* plants per plot which were either in flower or in bud, week 24 2018. Differences between treatments are not statistically significant.

Treatment	No in flower (out of 5)	No. in bud (out of 5)
Nursery standard	0.33	1.33
Prototype 3 (1st Gen)	0.33	2.33
Prototype 4 (2nd Gen)	0.33	1.33
Prototype 5 (2nd Gen)	0.33	1.33
Prototype 6 (2nd Gen)	0.67	2.00
Prototype 7 (2nd Gen)	0.00	2.00
F pr.	0.808	0.858
l.s.d.	0.996	2.293

There were significant differences between treatments for plant height (p <0.001, l.s.d = 2.367). The tallest plants were grown in the nursery standard, with an average height of 25.2 cm. The shortest plants were grown in prototype 7 with an average height of 18.1 cm. Plant height in prototype 3 and prototype 5 was not significantly different to the nursery standard (**Figure *37***). Prototype 7 was the only treatment where the plants were significantly shorter than all other treatments.

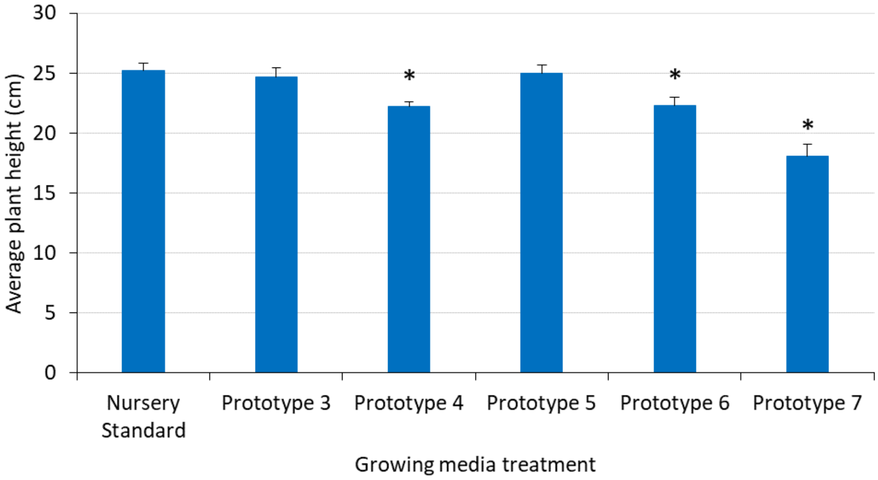


Figure 37. Average height (cm) of *Fuchsia* plants grown in different growing media blends. Differences across treatments are statistically significant (p <.001, l.s.d = 2.367). Error bars represent 1 standard error, with 5 degrees of freedom (d.f.). * = treatments are significantly different to the nursery standard.

Root development within each treatment was not significantly different. The highest level of root development was seen in prototype 4, with a score of 3.0. The nursery standard scored 2.93, and the lowest score for root development was seen in prototype 7, with a score of 2.2.

As with the *Pelargonium*, there were significant differences between treatments for both fresh and dry weight of the *Fuchsia* plants (p =0.006, l.s.d = 7.76 and p <0.001, l.s.d = 0.6287 respectively). The greatest fresh weight was recorded in prototype 5 (34.37 g per plant), closely followed by the nursery standard (33.12 g per plant). The lowest fresh weight was recorded in prototype 7 (16.82 g per plant), and this was significantly lower than all other treatments. The dry weights were similar to the fresh weight, with the greatest dry weight in prototype 5 (3.95 g per plant). However, with the dry weight, both prototypes 6 and 7 were significantly lower than the nursery standard.

Summer pack trials

Pelargonium

Differences between treatments for plant quality were statistically significant (p =0.011, l.s.d = 0.870). All treatments however scored above 3.0, which is the minimum score required to be deemed commercially acceptable. The highest plant quality was seen in the nursery standard (4.75), closely followed by prototypes 3 and 5, which both scored 4.50. The lowest plant quality was seen in prototype 7 (3.25). These plants were more compact, and had not yet reached pack cover, unlike the other treatments. The *Pelargonium* were left to grow on until week 30, to see whether prototype 7 would reach pack cover, which it did, however the plants remained smaller than the other treatments and did not catch-up. **Figure 38** shows the differences in plant quality between the nursery standard, prototype 3 and prototype 7.

Figure 38. *Pelargonium* 'Savannah' grown in different growing media blends at the final assessment, week 24. L-R: nursery standard, prototype 3 and prototype 7.

There were very few flowers or buds in the *Pelargonium* trial in week 24, so the plants were left to grow on until week 30. There were no differences in flowering time between treatments, and no significant difference in the number of plants in flower per pack.

The height of the *Pelargonium* plants produced in different growing media blends was significantly different (p =0.043, l.s.d = 1.192). The tallest plants were produced in the nursery standard (6.28 cm), and this was significantly greater than prototypes 4, 6 and 7 (4.84 cm, 4.94 cm and 4.38 cm respectively). Prototypes 3 and 5 were not significantly different to the nursery standard (5.78 cm and 5.19 cm respectively).

Root development was rather poor across the trial, with significant differences between treatments (p <0.001, l.s.d = 0.3508). The greatest root development was in prototype 5 (score of 1.94), with the nursery standard scoring 1.81. The lowest scoring treatment was prototype 7, with a root development score of 1.13.

There were significant differences between treatments for both the fresh and dry weights (p =0.002, l.s.d = 0.770 and p =0.021, l.s.d = 0.3875 respectively, **Figure 39**). Plants with the greatest fresh weight were produced in prototype 3 (4.29 g per plant), this was not significantly different to the nursery standard (3.77 g per plant) or prototype 5 (3.67 g per plant). The lightest plants were produced in prototype 7 (2.54 g per plant). The dry weight results generally mirrored the fresh weight, with the greatest dry weight in prototype 3, followed by the nursery standard. The lowest dry weight was recorded in prototype 6, with both prototypes 6 and 7 significantly lighter than the nursery standard.

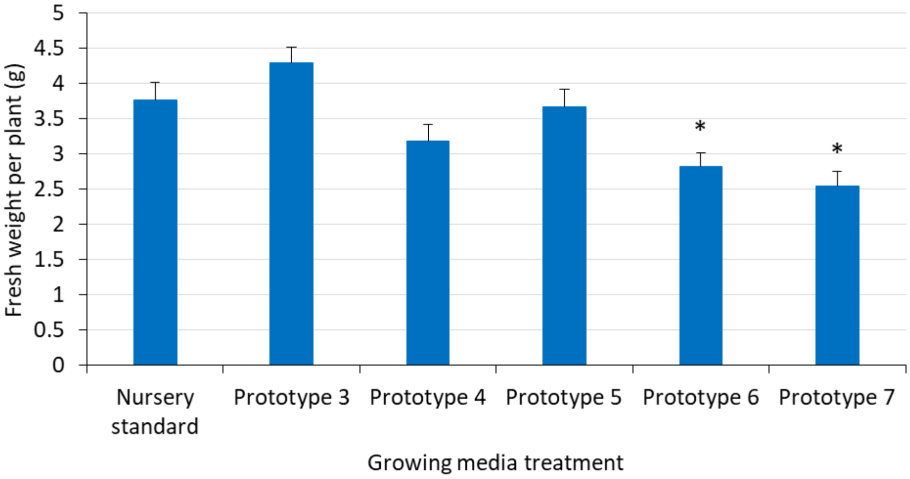


Figure 39. Average fresh weight of *Pelargonium* 'Savannah' grown in different growing media blends, week 24. Differences across treatments are statistically significant (p =0.002, l.s.d = 0.770). Error bars represent 1 standard error, with 5 degrees of freedom (d.f.). * = treatments are significantly different to the nursery standard.

Petunia

There were no significant quality differences between treatments in the pack Petunia trial. The highest quality score was given to the nursery standard (5.0) and the lowest quality score was given to prototypes 4 and 7 (4.5). All plants had grown well and reached pack cover, and there were no issues with foliage colour or flower size. There were also no significant differences in time to flower, or the number of plants per pack in flower in week 24. Prototype 4 had the greatest number of plants per plot in flower (18 out of 20), the nursery standard had an average of 17 plants out of 20 in flower, and the lowest number was in prototype 7, with an average of 16.75 plants per plot in flower out of 20. **Figure 40** shows a comparison between the nursery standard, prototype 4 and prototype 7 at the final assessment.

Figure 40. Petunia 'Frenzy' grown in different growing media blends at the final assessment, week 24. L-R: nursery standard, prototype 4 and prototype 7.

There was no significant difference between treatments for plant height. The tallest plants were produced in prototype 6 and the nursery standard (14.6 cm), and the shortest plants were grown in prototype 7 (12.3 cm). In terms of root development, differences between treatments were significant (p =0.008, l.s.d = 0.6098). The greatest level of root development was seen in prototypes 4 and 5, these treatments were scored as 2.75 and were significantly better than the nursery standard, which scored 2.1. The lowest root score of 1.6 was given to prototype 6, however this was not significantly different to the nursery standard. There were significant differences between treatments for both the fresh and dry weights (p =0.009, l.s.d = 1.078 and p =0.001, l.s.d = 0.2690 respectively). The greatest fresh weight was recorded in the nursery standard (7.49 g per plant) and this was significantly greater than prototypes 3, 4 and 7 (6.00 g, 5.42 g and 6.18 g respectively, **Figure 41**). The fresh weight of plants grown in prototypes 5 and 6 was not significantly different to the nursery standard. The differences in the dry weight reflected those seen in the fresh weight, with the greatest dry weight in the nursery standard, and the lowest in prototype 4. The dry weight for the nursery standard was significantly greater than all of the experimental prototypes.

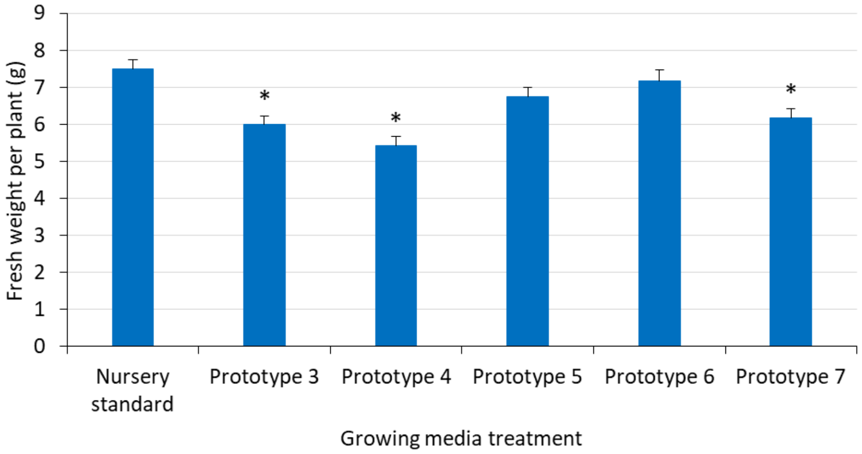


Figure 41. Average fresh weight of Petunia 'Frenzy' grown in different growing media blends, week 24. Differences across treatments are statistically significant (p =0.009, l.s.d = 1.078). Error bars represent 1 standard error, with 5 degrees of freedom (d.f.). * = treatments are significantly different to the nursery standard.

Autumn pack trial

Pansy

At the final assessment in week 44, there were no significant differences between treatments for plant quality. All packs had grown well, producing good quality plants which filled the packs, the foliage was a good colour and there were no issues with flower development or colour. Plants grown in the nursery standard, prototype 4 and prototype 5 all scored 5.0, and the remaining three prototypes all scored 4.7 for quality. **Figure 42** shows prototype 4 and prototype 7 compared to the nursery standard.

Figure 42. Pansy 'Inspire' grown in different growing media blends at the final assessment, week 44. Left: nursery standard (top) and prototype 4 (bottom). Right: nursery standard (top) and prototype 7 (bottom).

There were significant differences in the number of plants per plot in flower and in bud (p =0.040, l.s.d = 2.712 and p =0.022, l.s.d = 2.550 respectively, **Table 13**). The nursery standard and prototype 7 had the greatest number of plants per plot in flower (10.5), with prototype 4 significantly lower (6.67). Prototype 4 however had the greatest number of plants per plot in bud (9.67), with prototype 7 the lowest (5.33).

Table 13. Number of Pansy plants per plot which were either in flower or in bud, week 44 2018. Figures in red are significantly different to the nursery standard.

Treatment	No in flower (out of 20)	No. in bud (out of 20)
Nursery standard	10.50	6.17
Prototype 3 (1st Gen)	7.67	8.33
Prototype 4 (2nd Gen)	6.67	9.67
Prototype 5 (2nd Gen)	8.17	7.33
Prototype 6 (2nd Gen)	8.50	8.17
Prototype 7 (2nd Gen)	10.50	5.33
F pr.	0.040	0.022
l.s.d.	2.712	2.550

Differences between treatments for plant height were not significant. The tallest plants were produced in prototype 5 (5.92 cm), followed by the nursery standard (5.82 cm). The shortest plants were produced in prototype 4 (5.18 cm). There was a significant difference in root development (p <0.001, l.s.d = 0.3208), with prototype 4 scoring 2.38, and prototype 5 scoring 2.33, both of which were significantly greater than the remaining four treatments, including the nursery standard which scored 1.96. The lowest root score was given to prototype 6 (1.71), however this was not significantly lower than the nursery standard.

The differences in fresh weight were not significant. The greatest fresh weight was recorded in the nursery standard (5.53 g per plant), closely followed by prototype 5 (5.31 g per plant). The lowest fresh weight was recorded in prototype 7 (4.59 g per plant). The differences in dry weight however were significant (p =0.044, l.s.d = 0.0692, **Figure 43**), although the trend was similar to the fresh weight. The greatest dry weight was in the nursery standard (0.61 g per plant), followed by prototype 5 (0.59 g per plant). The lowest dry weight was recorded in prototype 7 (0.51 g per plant).

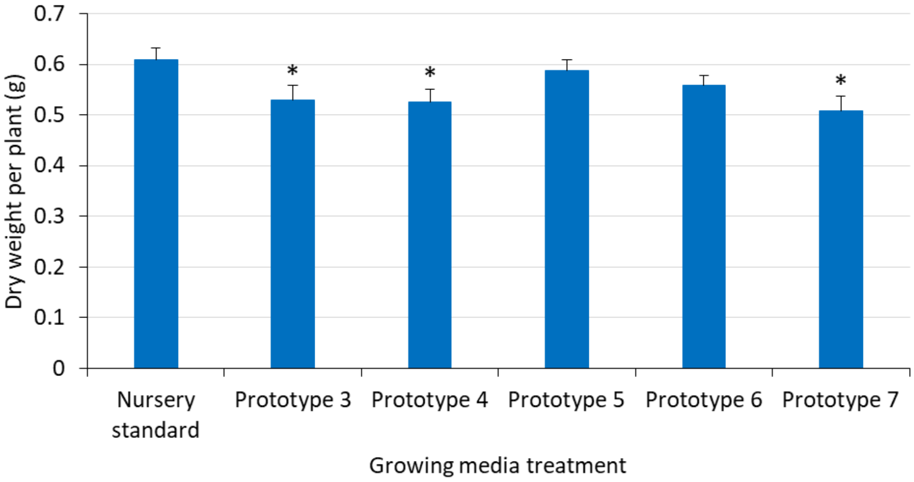


Figure 43. Average dry weight of Pansy 'Inspire' grown in different growing media blends, week 44. Differences across treatments are statistically significant (p =0.004, l.s.d = 0.0692). Error bars represent 1 standard error, with 5 degrees of freedom (d.f.). * = treatments are significantly different to the nursery standard.

Discussion

In summary, all prototypes, with the exception of prototype 7, worked very well and produced plants that were comparable to the nursery standard, and of high quality. Differences were more noticeable in the summer pack trials, which suggests that under extreme conditions such as those experienced in the summer of 2018, management of the prototype blends may need to be refined, in order to get the desired growth response.

Prototypes 3, 4 and 5 were all promising, with some good results within each trial. These blends had quite an open structure, allowing for good root development. Prototypes 6 and 7 on the other hand did not perform as well, and may have proved problematic for bedding plant production.

Overall, no single prototype stood out as a better performer, which indicates that a range of materials blended in different ways can all be suitable for pot and pack bedding plant production.

Conclusions

In the 2018 grower trials, differences between treatments were more noticeable using the 2nd generation blends (prototypes 4-7), which is to be expected as these blends were designed to be more 'extreme'. That said, all blends, with the exception of prototype 7, worked well in pot and pack bedding production and vegetable propagation. As seen in previous trials, there were differences between the crop sectors, with prototype 6 performing well in vegetable propagation and prototypes 4 and 5 standing out in pot and pack bedding production. Reassuringly, the 1st generation prototype blends gave good results in the 2018 trials (prototype 1 in vegetable propagation and prototype 3 in bedding production), demonstrating consistency across sites, plant types and growing season. Overall, the results show that taking a modelling approach to create new growing media blends with a particular set of physical characteristics can result in a marketable crop.

Third generation prototype blend testing – "pre-campaign" selection for 2019 grower hosted trials

A different approach was taken for the third generation prototype blend trials at ADAS Boxworth in 2018. These trials were designed to start testing the model, by introducing new raw materials which had not been available at the start of the project in 2015. A range of new materials were supplied by the growing media manufacturers, which included; a new woodfibre, pumice, anaerobic digestate, biochar, fine grade bark and oilseed rape fibre. The materials were characterised for their physical and chemical properties, and four were selected on the basis of their physical properties. The focus of this testing is for model development, using selected physical raw material properties. The four materials selected for experimental testing in 2018 are denoted by M1, M2, M3 and M4. A total of 18 blends were created to give a range of physical properties, these blends comprised single component media as well as mixtures of the materials (**Appendix 7**). These blends were tested against a peat standard, and a small selection will be taken forward into grower trials in 2019. All data were analysed using Analysis of Variance (ANOVA) with use of Duncan's multiple range test to separate treatments. The test was used with a 95% confidence level.

The trials at ADAS Boxworth used a bespoke Priva single line irrigation and feed delivery system. Due to the number of growing media blends identified for testing a single irrigation and feeding regime was used. Plants were irrigated as required, and a feed mix with a target concentration of 100 ppm nitrogen (N) was used (**Appendix 7**).

Protected Ornamentals – Pot Chrysanthemum

Methods

The trial was conducted in the polytunnel testing facility at ADAS Boxworth using cuttings of Chrysanthemum Chrystal Blanche. Cuttings were sourced from Dümmen Orange via Double H Nursery (Hampshire, BH25 5NG) and delivered to ADAS Boxworth in week 24 (12 June 2018). The cuttings were stored in a refrigerator at 5°C for 3 days, and were stuck into 14 cm pots, filled with the relevant growing media, on 15 June 2018. The media was wetted-up within the pots before the cuttings were stuck, and four cuttings were stuck into each pot. The pots were then lightly irrigated overhead after sticking. A total of 152 pots were used, with each bench section holding 38 pots. One bench was used for this trial, divided into four sections, with each section measuring 1200 mm by 1900 mm and containing one ebb and flood tray unit.

Immediately after sticking, the pots were placed pot-thick within plastic bread crates in a randomised trial design, set down on the bench, and covered with white polythene, taking care not to rest the polythene on the cuttings (**Figure 44**). The top of the bench was covered in two layers of green shade netting, which remained in place for the duration of the trial. The pots were lightly irrigated overhead on a daily basis until week 27 (04 July), when the cuttings had fully rooted, and the polythene was removed. The pots were then ebb and flood irrigated once per day, and remained pot-thick until week 31. The plants were then spaced out evenly on the bench to ensure even watering. Because of the time of year and absence of climate control / heating within the polytunnel (i.e. no blackouts), it was not possible to take the plants through to flowering. The plants were also not pinched, as would be done commercially, because an accurate assessment of biomass production at the end of the trial was required. It was however possible to grow the plants enough to gather useful data to select for commercial production trial growing media blends for 2019.

Figure 44. Bench set-up with plants covered with white polythene and green shade netting. Plants were watered overhead until week 27, and then via ebb and flood.

The plants were monitored for pest, disease and nutritional issues during the trial, and biocontrols were introduced on a weekly basis for aphid and thrips control (*Aphidius colemani* and *Neoseiulus cucumeris*). The plants were assessed at four, seven and 10 weeks after sticking for quality (scale of 0-5), plant height and numbers of dead cuttings per pot. For scoring criteria see **Appendix 8**. At the final assessment 10 weeks after sticking (week 34, 22 August 2018), the same criteria were assessed, along with root quality (scale of 0-4), and fresh and dry weight for the first four replicates (76 plots). Plants were dried in the oven at 80 ˚C for 48 hours to obtain dry weights. From the remaining four replicates, two plants of each treatment were watered to capacity, allowed to drain for four hours, and then placed into shelf life for 14 days. The plants were then monitored daily, and the day of plant wilting recorded. The shelf life room was set to 18°C, 12 hours light/dark.

Results

The quality of the chrysanthemum plants was significantly different at the first assessment, four weeks after sticking (p <0.001, l.s.d = 0.6209) with the majority of the treatments scoring lower than the peat standard (T1) (which scored 4.9). Only T5, T14 and T16 were not significantly different to the standard. The poorest plants were in T2 (score of 2.4) and T8 (score of 2.0).

At the second assessment seven weeks after sticking, the quality of the plants grown in T1 remained high with a score of 4.9, which was significantly better than all other treatments (p <0.001, l.s.d = 0.5203). However, the plants grown in T5, T14, T16 and T19 were still of very good quality, scoring 4.1, 3.9, 4.3 and 3.8 respectively. T10 was now the poorest performing blend, followed by T8 and T2.

At the final assessment, T5 and T16 were not significantly different to the standard (**Figure 45**). All other treatments were significantly lower quality (p <0.001, l.s.d = 0.5415). Both T5 and T16 had filled out to produce a large, full plant, which covered the pot nicely, and the foliage was healthy and green. The treatments which scored below 3, and therefore were unmarketable, were; T2, T4, T8, T9, T10 and T11. These plants had not grown and filled out enough to produce a full marketable plant, and the stems were generally thinner. T10 in particular was very pale and some of the plants were quite soft. Some of T4 and T9 were also pale. **Figure 46** shows a comparison between the peat standard, the highest performing treatments, and the lowest.

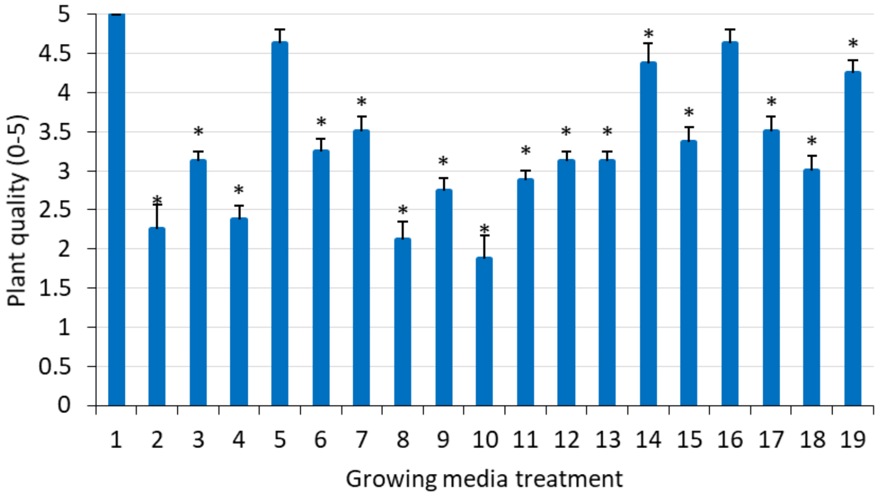


Figure 45. Average Chrysanthemum quality (scored 0-5) in different growing media blends 10 weeks after sticking, week 34. Differences across treatments are statistically significant (p <0.001, l.s.d = 0.5415). Error bars represent 1 standard error, with 18 degrees of freedom (d.f.). * = treatments are significantly different to the peat standard (T1).

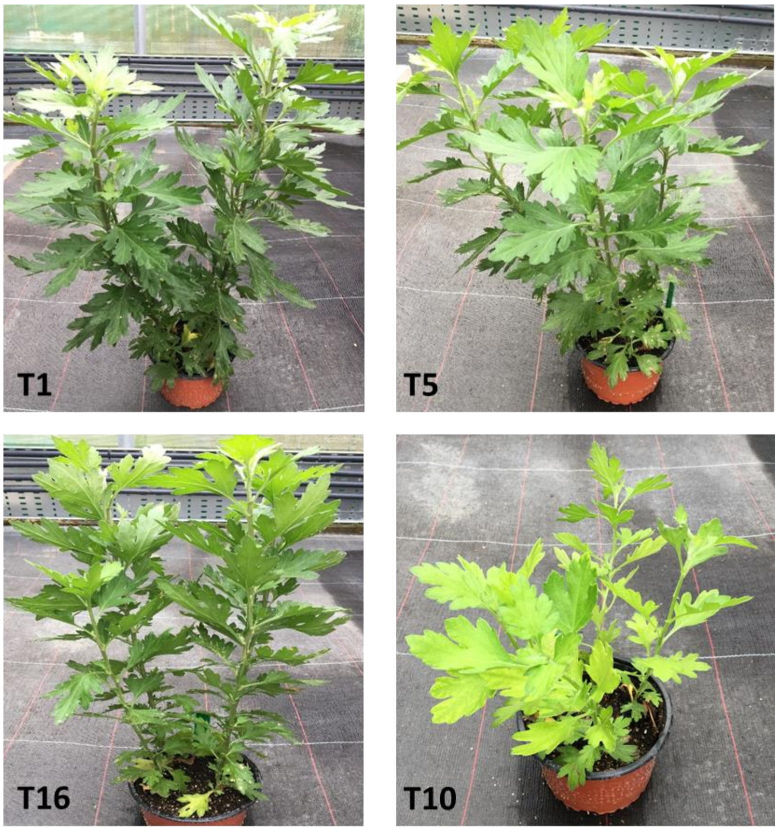


Figure 46. Plants grown in T1, T5, T16 and T10 at the final assessment, 10 weeks after sticking, 22 August 2018, week 34.

There was some plant death early on in the trial, with a significantly higher number of failed cuttings per pot (p <0.001, l.s.d = 0.6313) in T4 (0.875) and T8 (2.125). At the final assessment, this had not changed, and there had been no more plant death. It is likely that the hot temperatures experienced in the polytunnel at the start of the trial, combined with the fact that T4 and T8 were “dry” low water retention blends (T8 was particularly dry and difficult to wet-up), may have been a significant causal factor for early growth cycle plant losses.

Height specification for marketable chrysanthemums at Double H is 18 – 24 cm. Because the plants were not pinched, some of the treatments exceeded this. Throughout the trial the peat standard was always the tallest treatment. By the second assessment, seven weeks after sticking, plants in T1, T5, T12, T14, T16 and T19 had already exceeded 18 cm. However, because some treatments were still a long way off meeting specification, all plants were kept on for a further three weeks. At the final assessment 10 weeks after sticking, T5 was the only treatment which was not significantly shorter than the peat standard (p <.001, l.s.d = 4.527, **Figure 47**). The peat standard had reached a height of 45.69 cm, and T5 measured 41.44 cm. All treatments surpassed the specification of 18 cm, however T2 and T3 only just exceeded this (18.56 cm and 18.41 cm respectively).

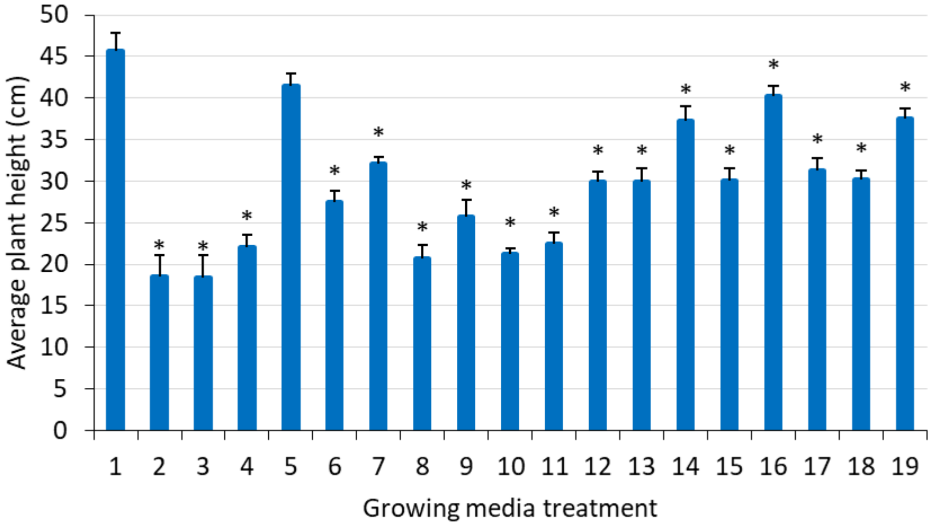


Figure 47. Average height of Chrysanthemum grown in different growing media blends 10 weeks after sticking, week 34. Differences across treatments are statistically significant (p <0.001, l.s.d = 4.527). Error bars represent 1 standard error, with 18 degrees of freedom (d.f.). * = treatments are significantly different to the peat standard (T1).

Width specification (at top of pot) for pot grown chrysanthemums at Double H is 25 – 30 cm. By the second assessment, seven weeks after sticking, plants in T1, T3, T5, T11 and T16 had just reached a width of 25 cm. After 10 weeks, T1 had produced the widest plants (27.25 cm), followed by T5, T16 and T19 (26.62 cm, 25.56 cm and 25.81 cm). These treatments were not significantly different to the peat standard (T1), all other treatments were significantly narrower and did not reach the minimum width specification of 25 cm (p <0.001, l.s.d = 2.609). The narrowest plants were produced in T2 (16.94 cm).

Root development was assessed once at the end of the trial, 10 weeks after sticking (week 34). The differences between treatments were significantly different (p <0.001, l.s.d = 0.4780) with the greatest root development in the peat standard (T1), T5 and T16 (all with a score of 4.0), followed by T14 (score of 3.75). These were the only treatments that were not significantly different to the standard. The lowest rooting scores were found in T2, T4, T8 and T9, which all scored 1.0, and were significantly different to the peat standard. Aside from T6 which scored 3.0, all other treatments scored below 3.0 (51-75 % coverage) and had quite a poor root system.

The fresh weight of the plants was closely related to plant height, with the greatest fresh weight in the peat standard (140.90 g). All other treatments were significantly lighter (p <0.001, l.s.d = 15.56), although T5 and T16 had a reasonable fresh weight (88.58 g and 95.38 g respectively), and were significantly better than all the other experimental treatments (**Figure 48**). The lowest fresh weight was seen in T2 (17.13 g), followed by T8 (19.13 g) and T4 (19.48 g).

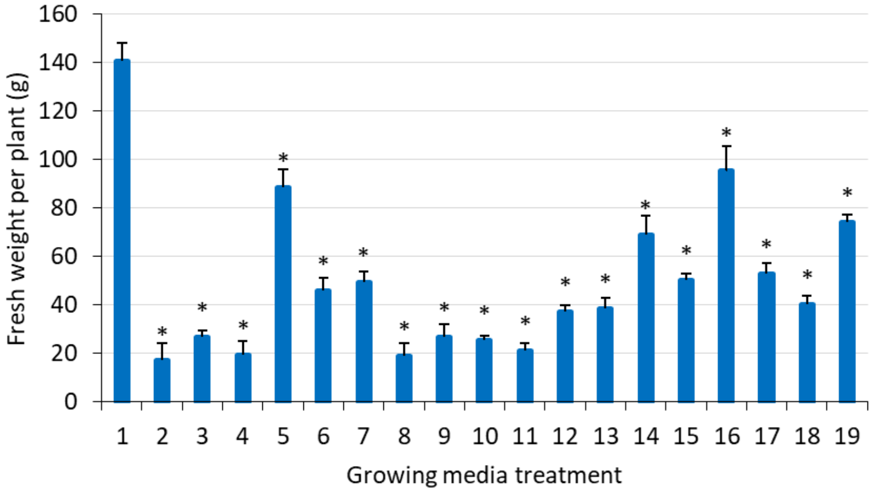


Figure 48. Average fresh weight of Chrysanthemum grown in different growing media blends 10 weeks after sticking, week 34. Differences across treatments are statistically significant (p <0.001, l.s.d = 15.56). Error bars represent 1 standard error, with 18 degrees of freedom (d.f.). * = treatments are significantly different to the peat standard (T1).

As expected, the dry weights mirrored the fresh weight, with the greatest dry weight in the peat standard (19.925 g) which was significantly greater than all other treatments (p <0.001, l.s.d = 2.872). The lowest fresh weight was recorded in T8 (1.9 g).

All treatments entered shelf life for 14 days, and the first plant to wilt was T1, six days into the test (28 August). The following day, the second T1 plant had started to wilt. This was followed by both T5 plants on 31 August. Because these plants had a visually larger leaf surface area, water loss from these plants may have been greater. From the 2 September to the 5 September, another nine plants from treatments T7, T8, T13, T16, T17 and T19 started to wilt. There was no plant death during the shelf life period.

Discussion

Throughout the trial, T5 performed well, and at the final assessment 10 weeks after sticking, it was the only treatment which was not significantly different to the peat standard for plant height, plant width or plant quality. T5 was 100% of material 2 (M2), which is fine grade, has a high water holding capacity and adequate air-filled porosity.

The other promising treatments were T14 (33% M2, 67% M4), T16 (67% M2, 33% M4) and T19 (33% M3, 33% M2 and 33% M4). These all contained a proportion of M2 which would have aided water retention, and the materials M3 and M4, which were both rather light, fibrous materials, would have increased the air-filled porosity and drainage characteristics of the growing media. It is interesting to note that combining M2 and M4, with one material making up two-thirds of the blend, and the other material making up one third of the blend, produced very similar results, regardless of which material made up two-thirds of the blend (T14 and T16). T19 was the only experimental blend that gave promising results and contained three materials, each added in as a third of the total blend.

Throughout the trial, T8 performed poorly, and resulted in some plant death early on in the trial. This treatment was 100% of M3, and was an extremely dry material, which was difficult to wet-up, and dried out very quickly. On its own it is clearly not suitable as a growing media material, but it does have promise if combined in relatively small amounts (up to one third) with other suitable materials.

Another poor performing treatment was T2, which was 100% of M1. Again, this material was very dry, and although it wouldn't be suitable on its own, it could be combined with other materials in a small amount to create a suitable blend.

Using M4 on its own (T12) gave mixed results, the plant height, width, quality and root development were ok, but fresh and dry weight was fairly low, so again, this is a material that works better when combined with other materials. Only M2 (T5) worked well on its own.

Hardy Nursery Stock

Methods

Liner plants of *Griselinia littoralis* and *Viburnum tinus* were supplied by James Coles and Sons Nurseries in week 30 (24 July 2018), and were potted into 2 L pots filled with the relevant growing media on 26 July 2018. Again there were 19 treatments (T1-T19, see **Appendix 9**). Each HNS species had 95 plants potted, with 190 plants in total. The pots were spaced out evenly on the benches to ensure even watering. Two benches were used for this trial, one for each plant species, and the benches were split into four sections, with each section measuring 1200 mm by 1900 mm. These sections were separated by Perspex to avoid any splash from adjacent sections and the bench itself was covered in capillary matting with micro-perforated plastic film on top (**Figure 49**). The plants were irrigated overhead using automatic sprinklers, which irrigated for four minutes every day. In week 41, the irrigation was reduced to every other day, and then in week 43, it was reduced further to three times per week.

Figure 49. Polytunnel set up with *Griselinia* and *Viburnum* on separate benches, with each bench divided into four sections. Plants were watered overhead by sprinklers.

The HNS plants were monitored for pest, disease and nutritional issues during the trial, and biocontrols were introduced on a weekly basis for aphid and thrips control (*Aphidius colemani* and *Neoseiulus cucumeris*). The plants were assessed at four week intervals during the trial, with a final assessment in week 46. At each assessment date, plants were assessed for quality (scale of 0-5) and plant height. At the final assessment in week 46, plants were also assessed for root development (scale of 0-4) and fresh and dry weight. Plants were dried in the oven at 80 ˚C for 48 hours to obtain dry weights. For scoring criteria see **Appendix 9**.

Results

Griselinia littoralis

At the first assessment, four weeks after potting, there were some obvious differences in plant quality between treatments, with treatments T2, T4, T8 and T9 all scoring less than 2.0, which was significantly different to T1 (peat standard), which scored 3.8 (p =0.003, l.s.d = 0.8712). The main reason for these low scores was that the plants had put on very little new growth, and looked paler than the other treatments. There was also some variability between plants in these treatments, with some plants looking better than others, so the scoring in these treatments was not consistent. T15 and T19 scored the same as the peat standard (3.8), and T12 actually scored higher than the standard (4.0) although this was not significantly higher. All other treatments were comparable to the peat standard.

At the next assessment, eight weeks after potting, one of the plants in T2, T4, T8 and T9 had died, and so these plants were no longer included in the assessments. It is likely that the hot temperatures experienced in the tunnel, combined with the nature of the materials making up these treatments, contributed to the plant death. In terms of statistical analysis, these plants were treated as missing values, and GENSTAT attributed an estimated value for each of these based on the other replicate plants of each treatment. T12 was still the highest scoring treatment (4.2), followed by T13 (3.8).

At the final assessment in week 46, T1 was the highest performing treatment (4.4), followed by T16 (4.2) and T3, T12 and T14 (all scoring 4.0). These plants had all put on plenty of new growth, the foliage was healthy and green and the plants had grown well. Treatments T2, T4, T8 and T9 were significantly poorer compared with the peat standard (p =0.018, l.s.d = 1.157) and did not score above 3.0, making them unmarketable (**Figure 50**). These plants had put on little growth, some of them had suffered from scorch and leaf damage, and one of the plants had died in each of these treatments. **Figure 51** shows a comparison between the standard, the highest performing treatments, and the lowest.

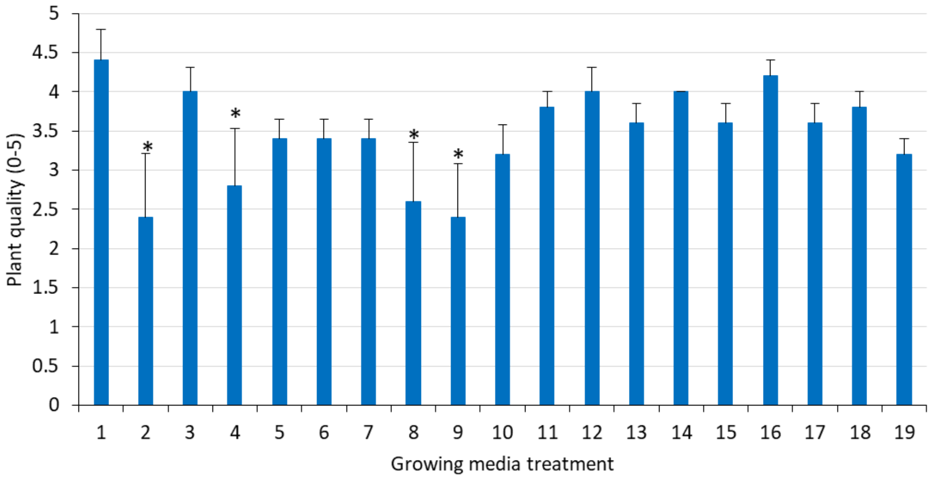


Figure 50. Average *Griselinia* quality (scored 0-5) in different growing media blends 16 weeks after potting, week 46. Differences across treatments are statistically significant (p =0.018, l.s.d = 1.157). Error bars represent 1 standard error, with 18 degrees of freedom (d.f.). * = treatments are significantly different to the peat standard (T1).

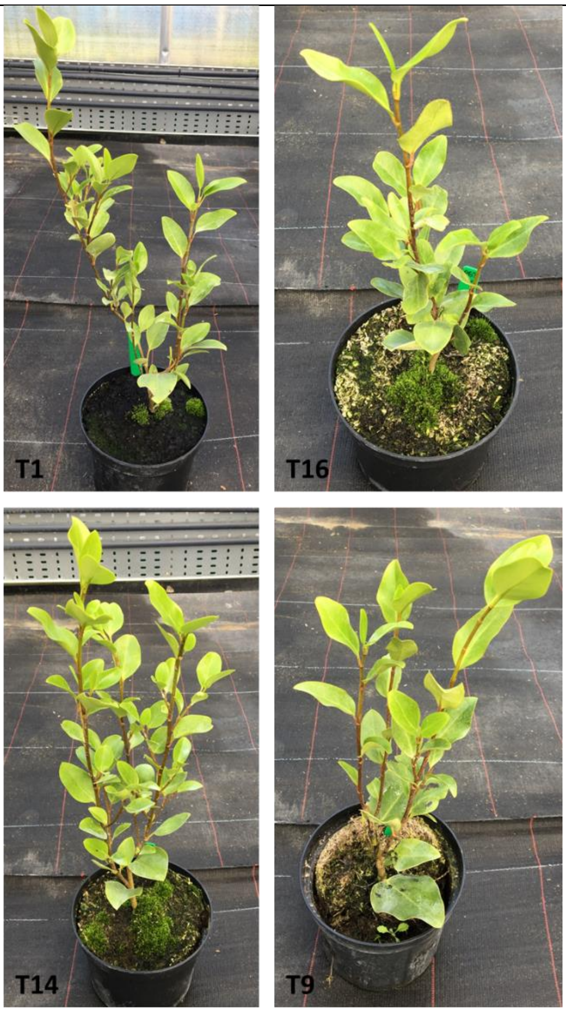


Figure 51. *Griselinia* grown in T1, T16, T14 and T9 at the final assessment, 16 weeks after potting, week 46.

There were no significant differences between any of the treatments at any of the assessments for plant height.

At the final assessment 16 weeks after potting, there was a significant difference in root development between treatments (p <0.001, l.s.d = 0.811). T1 (peat standard) had the highest root development score (4.0), meaning there was plenty of white root throughout the pot. T12, T13, T16 and T19 also had good root development, and were not significantly different to T1. The poorest root development was in T9 (0.93) where there was very little root produced. T2, T4, T8, T9, T17 and T18 all scored less than 2.0, which meant that less than 50% of the pot contained roots.

The greatest fresh weight was recorded in T1, with an average plant weight of 35.22 g. T12 and T14 also had reasonable fresh weights, weighing an average of 31.38 g and 30.38 g respectively. There were eight treatments with a fresh weight which was significantly lower than the peat standard (p =0.010, l.s.d = 8.444; **Figure 52**). The lowest fresh weight was recorded in T8, with an average weight of 18.72 g.

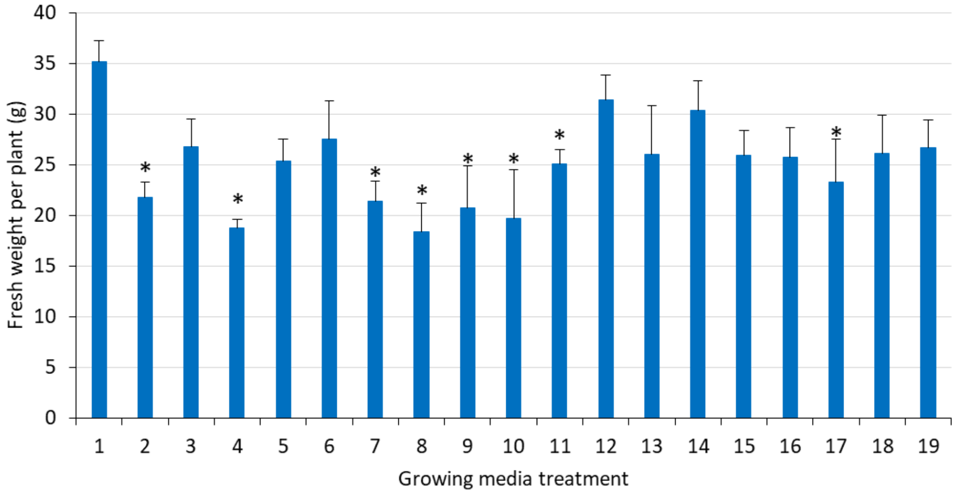


Figure 52. Average fresh weight of *Griselinia* grown in different growing media blends 16 weeks after potting, week 46. Differences across treatments are statistically significant (p =0.010, l.s.d = 8.444). Error bars represent 1 standard error, with 18 degrees of freedom (d.f.). * = treatments are significantly different to the peat standard (T1).

The dry weight was very similar to the fresh weight, with the greatest dry weight in T1 (9.88 g). There were seven treatments with significantly lower dry weights than the peat standard (p =0.021, l.s.d = 2.475). The lowest dry weight was recorded in T4 (5.17 g), followed by T8 (5.27 g).

Viburnum tinus

At the first two assessments, four and eight weeks after potting, there were no significant differences in plant quality between any of the treatments. At the third assessment, 12 weeks after potting, the highest scoring plants were in the peat standard (4.4), and seven of the treatments scored marginally lower than the standard (p =0.052, l.s.d = 0.654). However, all of the treatments still scored 3.0 or above, which meant that they were still marketable.

At the final assessment, 16 weeks after potting, there had been little change in plant quality. The peat standard remained the highest scoring treatment (4.4), and now there were nine treatments which were significantly lower than the standard (p =0.006, l.s.d = 0.692), but again, all treatments scored 3.0 or above which meant that they were of marketable quality. The lower scores were mainly due to leaf scorch on some leaf tips, which may have been caused by a combination of the hot weather and plant stress in some of the blends. There were no plant deaths in the *Viburnum* trial. **Figure 53** shows a comparison between the standard, the highest performing treatments, and the lowest.

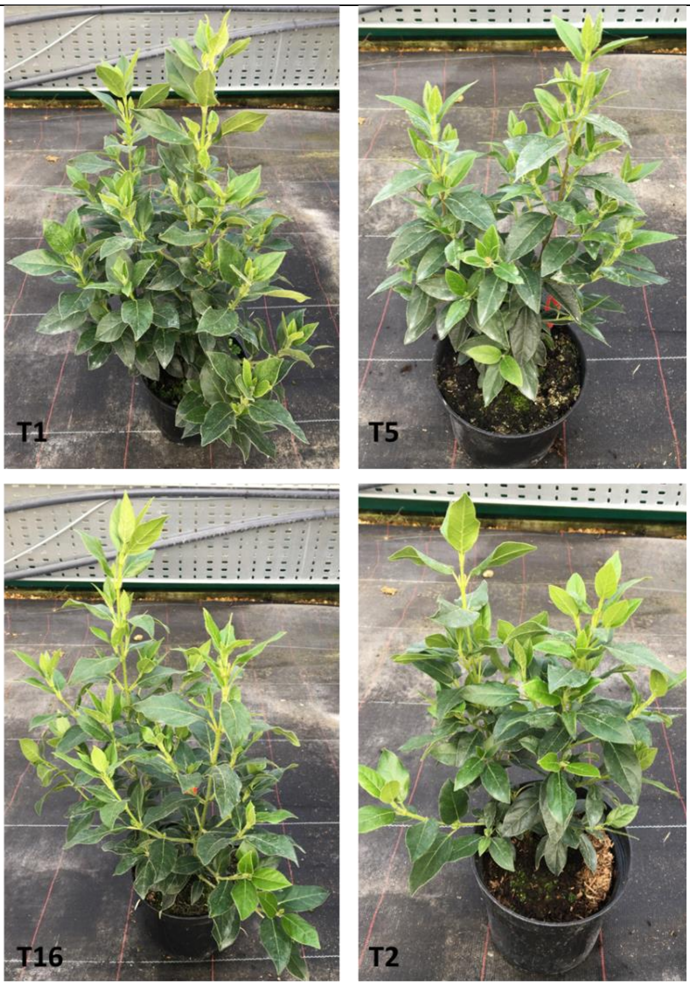


Figure 53. *Viburnum* grown in T1, T5, T16 and T2 at the final assessment, 16 weeks after potting, week 46.

There were no significant differences between any of the treatments at any of the assessments for plant height.

At the final assessment 16 weeks after potting, there was a significant difference in root development between treatments (p <0.001, l.s.d = 1.017). T1 had the highest root development score (3.8), meaning there was plenty of white root throughout the pot, and the majority of the treatments had good root development, scoring 2.4 or above (**Figure 54**). There were five treatments however (T2, T8, T9, T10 and T18) which scored significantly lower than the peat standard, with the lowest score in T10 (1.4). In these treatments, less than 50% of the pot contained roots.

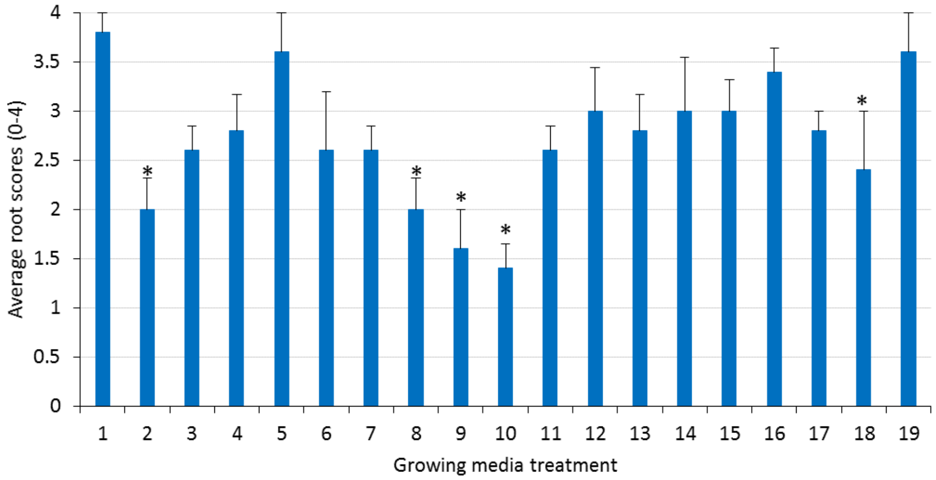


Figure 54. Average root scores for *Viburnum* grown in different growing media blends 16 weeks after potting, week 46. Differences across treatments are statistically significant (p <0.001, l.s.d = 1.017). Error bars represent 1 standard error, with 18 degrees of freedom (d.f.). * = treatments are significantly different to the peat standard (T1).

There were no significant differences between treatments for either fresh weight (p =0.381, l.s.d = 27.58) or dry weight (p =0.196, l.s.d = 9.654), 16 weeks after potting.

Discussion

Overall, all growing media treatments worked to some extent in the *Viburnum* trial. However, if a growing media product was required that would be suited to a range of plant species, including more sensitive species such as *Griselinia*, then T3, T12, T14 and T16 would all be suitable. T3 contains one third M2 and two thirds M1. This is quite a fine blend, with good air filled porosity and available water. T12 contains 100% M4, which is quite light and fibrous, and so would drain nicely, which may help to explain why the *Griselinia* did well in this treatment, as they like a well-drained media. T14 contains one third M2 and two thirds M4, and T16 contains two thirds M2 and one third M4, so this combination of materials works well for HNS production. M2 is a fine material which can hold onto water quite well, so when combined with M4, it helps to create a media blend which has both good water holding capacity, and air-filled porosity.

The poorer treatments were T2, T4, T8, T9 and T10. Two of these blends contain 100% of a raw material (T2 = 100% M1 and T8 = 100% M3). T4 and T9 then contain both of these raw materials in large quantities, and T10 also contains a large amount of M3. The results suggest that using these materials on their own, or combined together in high proportions, might not always result in a marketable crop, but there is the potential to use them in smaller amounts combined with other suitable raw materials.

Protected edibles – Pot herbs

Methods

Seeds, plugs and pots were supplied by Vitacress Herbs (Chichester, PO20 1LJ) in July 2018 (seed) and September 2018 (plugs). Two separate trials were run for the herbs, one in summer (basil and coriander sown week 29) and one in autumn (rosemary plugs potted week 36). For the basil and coriander trial, blends were mixed at ADAS Boxworth, and transferred to Vitacress Herbs. The blends were wetted-up prior to use, the pots were labelled and filled by nursery staff, and the pots were sown using an automatic sowing machine in week 29. The pots were then set out on the nursery, so that the germination phase could be completed under commercial conditions. The basil seed was not topped with any growing media, but the pots were covered with white plastic until germination. The coriander seed was topped with a very thin layer of the nursery's commercial standard product, but not covered with any plastic. The topping was unlikely to affect results. Once the seed had germinated, the pots were transferred to ADAS Boxworth in week 31, and set-out on the bench within the polytunnel in a randomised trial design (**Appendix 10**). The bench was covered with a single layer of green shade netting, to help prevent the pots from drying out completely in the hot weather.

For the rosemary trial, plugs were delivered to ADAS Boxworth in week 36, pots were filled with the relevant growing media and wetted-up, and the plugs were potted by hand. One bench was used for each trial, and the bench was split into four sections, with each section measuring 1200 mm by 1900 mm and containing one ebb and flood tray unit.

The pots were spaced out evenly on the bench to ensure even watering (**Figure 55**), and were irrigated once per day using the ebb and flood system.

Figure 55. Basil plants set out on the bench in a randomised design, the bench was covered with green shade netting. Plants were watered once per day via ebb and flood.

The coriander and basil were assessed in week 34 (24 August) and week 35 (30 August) respectively. For each plot, the plants were assessed for quality (scale of 0-3, where 0 = dead, 1 = obvious quality issues not suitable for dispatch, 2 = very minor quality issues ok to dispatch 3 = perfect no quality issues), plant height and the number of germinated seeds per pot. Fresh and dry weight was recorded for the first six replicates (114 plots). Plants were dried in the oven at 80 ˚C for 48 hours to obtain dry weights. The remaining two replicates, two plants of each treatment, were sleeved, and placed into shelf life for 14 days. The plants were only watered once to capacity before entering shelf life. The plants were then monitored daily, and the day of plant wilting recorded. The shelf life room was set to 18°C, with 24 hour light.

All of the rosemary plots were assessed in week 43 for quality (scale of 0-3 as above), plant height and fresh and dry weight.

Results

Basil

When germination was assessed at the end of the trial, T16 and T19 had significantly greater germination (85.4% and 86.3%) than the peat standard (64%), ($p < 0.001$, l.s.d = 17.03). T2 was the only treatment to have significantly lower germination (31.5%) than the standard. All other treatments were not significantly different to the peat standard.

The height specification for basil at Vitacress is 17 cm. The tallest plants were produced in the peat standard (17.75 cm), followed by T14 (16.81 cm), which was not significantly different to the standard (**Figure 56**). All other treatments were significantly shorter than T1 (p <0.001, l.s.d = 1.97). The shortest plants were produced in T2 (1.12 cm) and T8 (2.5 cm). Although the peat standard was the only treatment to measure over 17 cm, there were a few treatments which were close to this, and would have likely reached 17 cm if they had been left to grow for another 5-7 days.

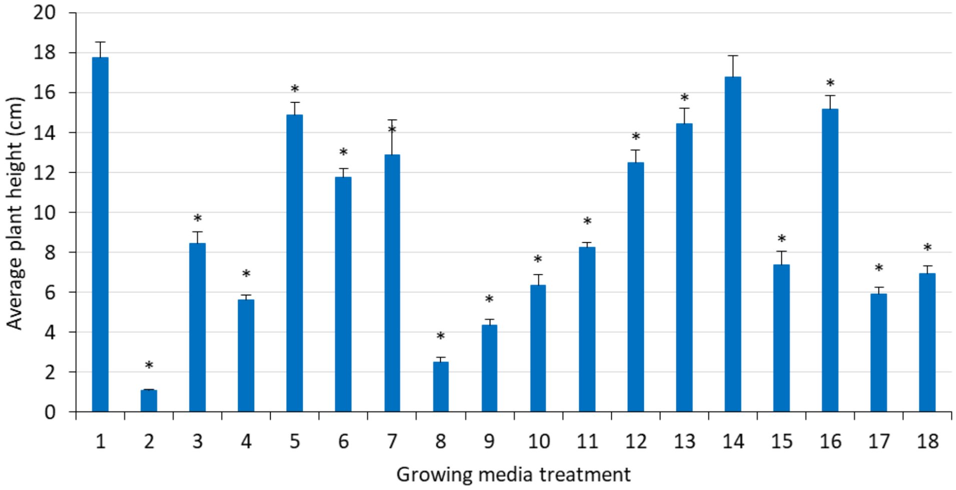


Figure 56. Average height of basil grown in different growing media blends, week 35. Differences across treatments are statistically significant (p <0.001, l.s.d = 1.97). Error bars represent 1 standard error, with 18 degrees of freedom (d.f.). * = treatments are significantly different to the peat standard (T1).

The quality of the basil plants was greatest in both T1 and T14, with a score of 2.75. The quality of the plants grown in T16 was 2.63, and this treatment, along with T14, were the only treatments which were not significantly different to the peat standard (T1). All other treatments were of significantly lower quality (p <0.001, l.s.d = 0.31) with the lowest quality seen in T2 (0.97). There were a number of treatments which scored below 2.0, making them unmarketable (**Figure 57**). **Figure 58** shows a comparison between the peat standard, the highest performing treatments, and the lowest.

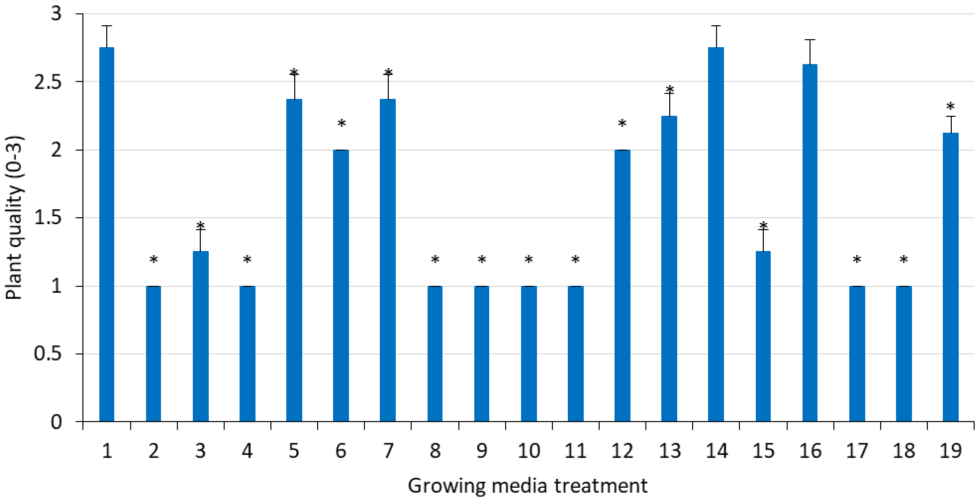


Figure 57. Average basil quality (scored 0-3) in different growing media blends, week 35. Differences across treatments are statistically significant (p <0.001, l.s.d = 0.31). Error bars represent 1 standard error, with 18 degrees of freedom (d.f.). * = treatments are significantly different to the peat standard (T1).

Figure 58. Basil grown in T1, T14, T16 and T4 at the final assessment, 30 August 2018, week 35.

The fresh weight of the basil followed a similar trend to the height, with T1 producing the greatest fresh weight (37.4 g). This was significantly greater than all other treatments (p <0.001, l.s.d = 3.77), although T5, T14 and T16 all produced relatively high fresh weights as well (24.87 g, 27.77 g and 30.78 g respectively). The lowest fresh weights were recorded in T2 (0.49 g), T8 (1.78 g) and T9 (2.53 g). The dry weight of the basil generally mirrored the fresh weight, with the greatest dry weight in T1 (2.95 g), which was significantly greater than all other treatments (p <0.001, l.s.d = 0.43). This was followed by T16, T14 and T5. The lowest dry weights were recorded in T2, T8 and T9.

All treatments entered shelf life for 14 days, apart from T2, which were too small to include in a shelf life test. Wilting started seven days into shelf life, with both plants from T1, T14 and T19 wilting, along with one plant from T5, T6 and T16. These were generally the bigger plants, which would have used up their water reserves faster than some of the other treatments, and so in shelf life would require more regular watering.

A number of other treatments began to wilt in the final seven days of shelf life, and some plant death was recorded in the last two days. These were generally the plants that had started to wilt earlier in the shelf life test.

Coriander

When germination was assessed at the end of the trial, there were a number of treatments with a higher percentage germination than the peat standard, which achieved 83.75% germination. However, none of these treatments were significantly better than the standard. The greatest level of germination was recorded in T11, with 96.67% germination. The lowest germination was recorded in T2, with 60.42%, and this was significantly lower than the standard (p <0.001, l.s.d = 13.72).

The height specification for coriander at Vitacress is 17 cm. The tallest plants were produced in the peat standard (18.1 cm), this was significantly greater than all other treatments (p <0.001, l.s.d = 1.46). There were a couple of treatments which were just below this height specification, they were T16 (16.6 cm) and T5 (16.2 cm). The shortest plants were produced in T2 (3.0 cm).

The quality of the coriander plants was greatest in both T1 and T5, with a score of 3.0. Another three treatments, T14, T16 and T13, were not significantly different to the peat standard (2.875, 2.75 and 2.625 respectively). All other treatments were of significantly lower quality ($p < 0.001$, l.s.d = 0.41) with the lowest quality seen in T2 (0.97). There were a number of treatments which scored below 2.0, making them unmarketable (**Figure 59**). **Figure 60** shows a comparison between the peat standard, the highest performing treatments, and the lowest.

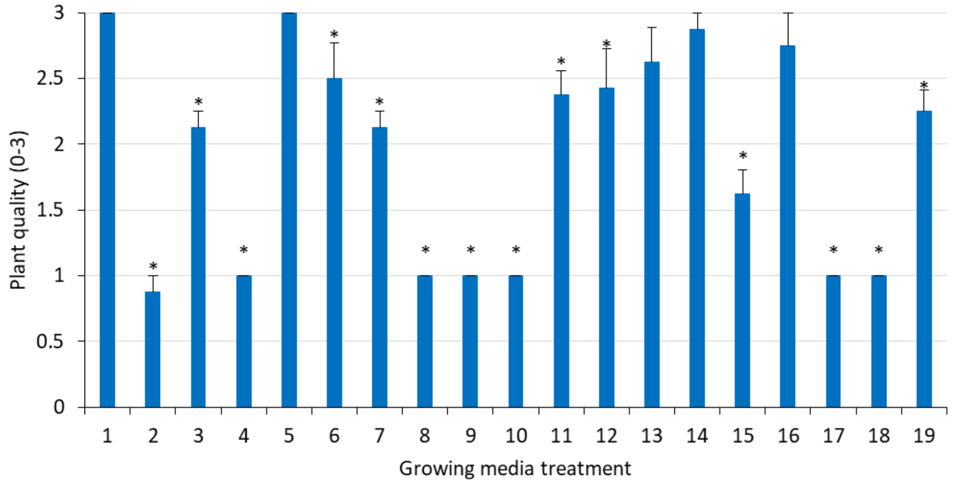


Figure 59. Average coriander quality (scored 0-3) in different growing media blends, week 34. Differences across treatments are statistically significant ($p < 0.001$, l.s.d = 0.41). Error bars represent 1 standard error, with 18 degrees of freedom (d.f.). * = treatments are significantly different to the peat standard (T1).

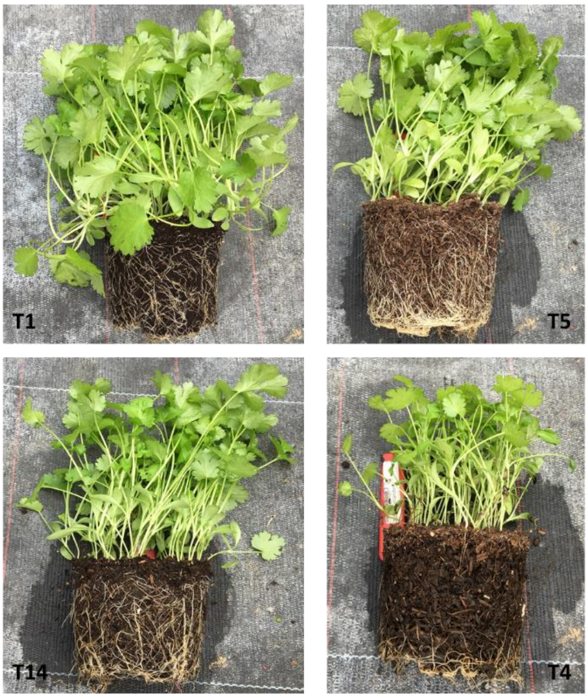


Figure 60. Coriander grown in T1, T14, T16 and T4 at the final assessment, 24 August 2018, week 34.

The greatest fresh weight was recorded in T1 (30.42 g), closely followed by T5 (27.08 g) (**Figure 61**). All other treatments were significantly lighter than the peat standard ($p < 0.001$, l.s.d = 4.44). However, T16 and T14 both produced pots that had a reasonable fresh weight (23.6 g and 20.02 g respectively). The lowest fresh weight was recorded in T2 (1.35 g). The dry weight of the coriander generally mirrored the fresh weight, with the greatest dry weight in T5 (2.55 g) and T1 (2.18 g), which was significantly greater than all other treatments (p <0.001, l.s.d = 0.44). This was followed by T16 and T14. The lowest dry weights were recorded in T2, T8 and T9.

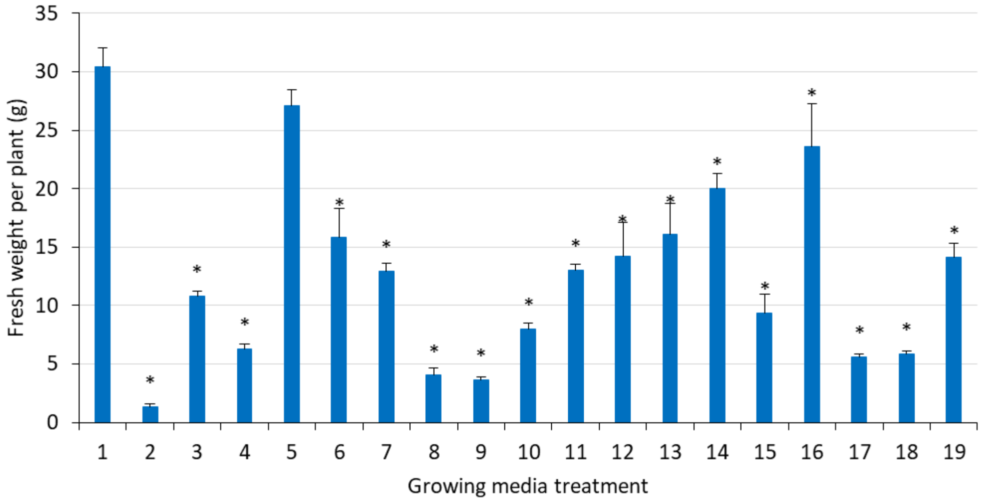


Figure 61. Average fresh weight of coriander grown in different growing media blends, week 34. Differences across treatments are statistically significant (p <0.001, l.s.d = 4.44). Error bars represent 1 standard error, with 18 degrees of freedom (d.f.). * = treatments are significantly different to the peat standard (T1).

All treatments entered shelf life for 14 days, and the first plant to wilt was T1, which started to wilt after six days in shelf life. As with the basil, it is most likely that this was because T1 produced the largest plants, and therefore would have required more watering in shelf life. There was less wilting in the coriander trial, with a few more plants starting to wilt in the last three days of the shelf life test. The lower leaves of these treatments were also starting to turn yellow. There was no plant death in the coriander shelf life.

Rosemary

The quality of the rosemary was greatest in T5, with a score of 2.5, followed by T14 and T1 (both 2.375). Another three treatments (T10, T16 and T19) were not significantly different to the standard. All other treatments were significantly poorer (p <0.001, l.s.d = 0.634) and scored less than 2.0, which made them unmarketable. The lowest scoring treatments were T4, T8 and T9, which all scored 0.125 (**Figure 62**). In T2, all the plants had died, and therefore are not included in the results. **Figure 63** shows a comparison between the standard, the highest performing treatments, and the lowest.

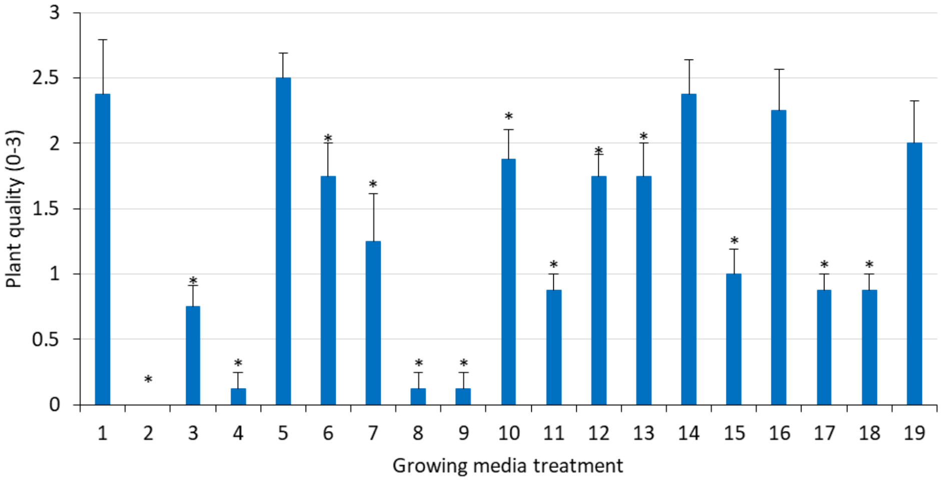


Figure 62. Average rosemary quality (scored 0-3) in different growing media blends, week 43. Differences across treatments are statistically significant (p <0.001, l.s.d = 0.634). Error bars represent 1 standard error, with 18 degrees of freedom (d.f.). * = treatments are significantly different to the peat standard (T1).

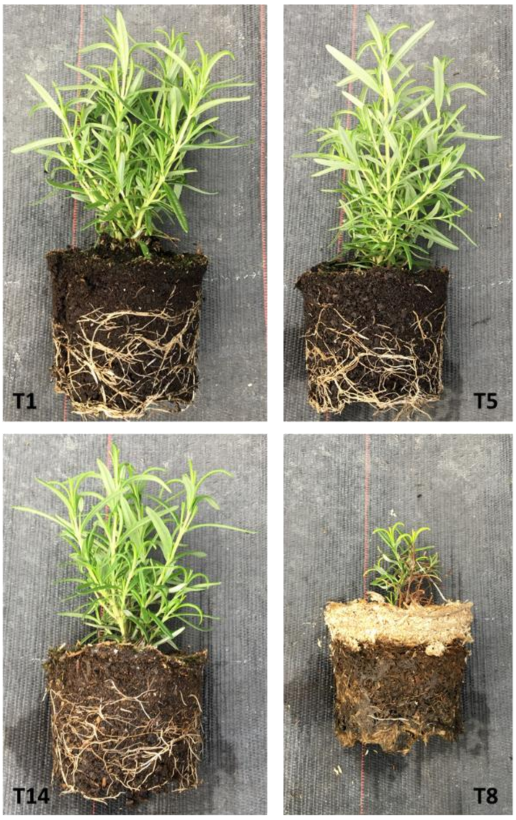


Figure 63. Rosemary grown in T1, T5, T14 and T8 at the final assessment, 26 October 2018, week 43.

The height specification for rosemary at Vitacress is 17 cm. However, because this trial was set-up towards the end of summer, the decreasing temperatures and the shorter day lengths meant that it was not possible to grow the rosemary on to the full height specification within a polytunnel. Therefore the plants were assessed once it was clear the peat standard had stopped growing, and the plants were not going to get any taller.

The tallest plants were produced in T6 (13.35 cm), followed by T5 (12.10 cm), T16 (11.55 cm), T14 (11.36 cm) and T1 (11.06 cm). None of these treatments were significantly different to each other. A number of other treatments were significantly smaller than the peat standard (p <0.001, l.s.d = 3.203), with the shortest plants recorded in T8 (3.275 cm) (**Figure 64**).

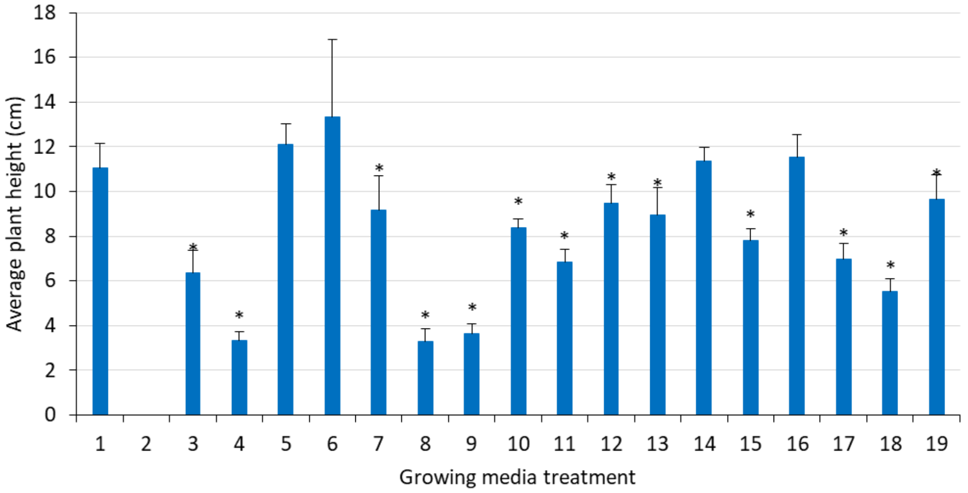


Figure 64. Average height of rosemary grown in different growing media blends, week 43. Differences across treatments are statistically significant (p <0.001, l.s.d = 3.203). Error bars represent 1 standard error, with 18 degrees of freedom (d.f.). * = treatments are significantly different to the peat standard (T1).

The greatest fresh weight was recorded in T5 (8.41 g), followed by T1 (7.40 g) and T16 (7.15 g). These treatments were not significantly different to each other, all other treatments were significantly lighter than the peat standard (p <0.001, l.s.d = 1.768). As the plants in T2 had died, the lowest recorded fresh weight was in T8 (0.36 g). The dry weight of the rosemary was similar to the fresh weight, with the greatest dry weight in T5 (1.49 g), T16 (1.29 g) and T1 (1.26 g), which were significantly greater than all other treatments (p <0.001, l.s.d = 0.287). The lowest dry weights was recorded in T8 (0.23 g).

Discussion

Across the three herb trials, T5, T14 and T16 all stood out as high performing blends, producing plants of a good quality which would be marketable. There were a couple of treatments which worked better for certain criteria for one species. For example, T11 produced the highest level of germination in the coriander trial, and the coriander was of a fairly high quality, but in the basil trial, T11 only gave moderate germination and the plants were of a relatively poor quality. Therefore, some growing media blends may be well suited to certain herb species, but not all.

There were also some slightly different results in the rosemary trial compared to the basil and coriander trials. In the rosemary trial, T6 was the better performing blend for crop height, and T10 and T19 produced good quality plants, but for the basil and coriander, T6 and T19 were only average performing blends, and T10 did not perform particularly well. This suggests that established plugs may be able to thrive in a wider range of growing media blends, because they are more robust than something growing from seed.

Across the three trials, T2, T8 and T9 were the poorest performing blends. T2 consists of 100% of M1 and T8 consists of 100% of M3. T9 contains two thirds M3 and one third M1. The results suggest that using these materials on their own, or combined together in high proportions does not result in a marketable crop, but there is the potential to use them in smaller amounts combined with other suitable raw materials.

Overall, it is promising that there are a few growing media blends, particularly T5, T14 and T16, which worked well for all the herb species tested, and also worked for both plug and seed production. T5 consists of 100% of M2, which is a rather fine material, with good water holding capacity. T14 contains one third M2 and two thirds M4, and T16 contains two thirds M2 and one third M4, so this combination of materials works well for herb production. M4 is a light, fibrous material, so when combined with M2, helps to create a media blend which has both good water holding capacity, and air-filled porosity.

Conclusions

The experimental trials in 2018 were designed to really start testing the model, by using a new set of materials which were relatively unknown, and seeing whether they could be blended in such a way that the physical properties of the blends would be suitable for plant growing, regardless of the materials making up those blends. There were some failures, but this is important to help strengthen and refine the model. There were however some very high performing blends, notably T5, T14, T16 and T19, which produced good quality plants in the different crop sectors (HNS, pot chrysanthemum and herbs). Promising blends from these trials will be tested on commercial nurseries in 2019 to see if these results can be replicated, or improved upon.

Mechanisation

In September 2018, all of the prototypes which have been used on grower holdings so far (Prototypes 1-7, not the Boxworth experimental blends), were tested at the Mechanical Botanical machinery depot to see how well they would flow through different types of machinery (**Figure 65**). 500 L of each prototype were mixed at STC and delivered to the depot, and as a starting point, a pot filling machine and a tray filling machine were tested. The machines were set-up by Mike Berry (Mechanical Botanical) ensuring that the machinery settings were suited to the material. Work was also overseen by John Adlam (Dove Associates).

Figure 65. Testing prototype blends on a pot filling machine (2 L pots) and a tray-filling machine (84-cell trays).

All blends were run through the pot filling machine first, in their raw state, i.e. no water was added to the blends for the first run. The number of 2 L pots filled using 500 L of each blend was recorded, and observations were made on how easily the material flowed, how well the pots filled, how well a crown was formed on the surface of the pot, and whether there were any issues with material slumping in the pots, or clogging the machine.

Once all blends had been tested with the potting machine, they were then wet-up to an even moisture, using a delta-T moisture probe, and run through the machine again. **Table 14** shows how many pots were filled when the blends were in both their raw state, and then wetted-up.

Table 14. Blend performance in potting machine using 500 L of each blend.

Prototype	Moisture (%)	No. of pots filled in raw state	No. of pots filled when wetted up to 22%	Comments (at 22% moisture)
1	9.9	235	206	Pots filled well
2	8.3	204	221	Pots filled nicely, dibbed hole held well
3	17	201	198	Pots filled very well. Good dibbed hole and crown
4	12.6	220	216	Pots filled well
5	13.5	208	208	Pots filled well, good dibbed hole
6*	22.8	197	N/A	Dibbed hole held well
7*	22.9	193	N/A	Dibbed hole held well

* Prototype 6 and 7 were not wetted up and re-tested as they were already of a suitable moisture.

The blends were then run through a tray-filling machine, and the number of 84-cell trays filled was recorded (**Table 15**). Due to the size of the hopper in the tray-filling machine, only 250 L of each blend was used.

Table 15. Blend performance in tray-filling machine using 250 L of each blend.

Prototype	No. of trays filled when wetted up to 22%	Comments
1	69	Material flowed nicely, trays filled well
2	73	Trays filled evenly
3	78	Material flowed nicely, trays filled well
4	93	Material kept jamming in recycling area of machine, not a constant flow
5	82	Material flowed nicely, trays filled well
6	55	Material flowed nicely, trays filled well
7	68	Material flowed nicely, trays filled well

There were no issues with the pot filling machine when using blends in their raw state, or wetted-up to an even moisture. All blends flowed through well, none of the material caused any blockages, and the pots were well filled with an even crown to the pots. The dibbed holes also held well and there were no issues with material slumping.

With the tray-filling machine, the only blend to cause any issues was prototype 4. This blend was particularly fibrous compared to the other blends, and there were some issues with the material clogging up the recycling section of the machine. The machine had to be stopped and the blockage cleared before tray-filling could continue. This slowed down the tray-filling process quite considerably. There were no issues with any of the other prototypes when using the tray-filling machine.

In 2019, any new prototype blends used on grower sites will be tested in the same way, and different size trays will also be used.

WP4: Workshop and knowledge exchange events

Knowledge exchange is an integral part of CP138, as important messages from the project need to be communicated to growers and the industry. Throughout 2018 the outputs and progress of CP138 were communicated to the industry through independent workshops, as well as continuing to attend and present at additional industry events. This allowed attendees to not only learn about the project and results gathered to-date, but to also view trials in-situ or be "shown in practice". Knowledge Exchange has not, however, been 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**). Knowledge Exchange activities completed to-date are detailed in **Table 16**.

Table 16. Knowledge Exchange completed to-date.

Date	KE 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).
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.
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.
07-08/12/2016	Event	HNS Substrate and Nutrition Workshops (Oxford and N. Yorkshire). Overview of project given by Neil Bragg.
Feb 2017	Magazine	AHDB Grower magazine article written by project team (Issue 230, page 16).
08/02/2017	Event	Herbaceous Perennial Technical Discussion Group meeting. Overview of project given by Barry Mulholland.
25/04/2017	Workshop	New Farm Produce workshop (Strawberries). Overview of project and view of trials. Talks from Janet Allen, Jude Bennison and Sam Brown (ADAS). Machinery demo from Mechanical Botanical and Farm Tour from Stephen McGuffie.
15/05/2017	Online magazine	Mini article in Horti Daily summarising the strawberry workshop (http://www.hortidaily.com/article/34533/UK-New-growing-media-blends-to-reduce-reliance-on-coir).
07/06/2017	Workshop	Vitacress workshop (Herbs). Overview of project and view of trials. Talks from Susie Holmes and Chloe Whiteside. Machinery demo from Mechanical Botanical and nursery tour from Simon Budge.
20/06/2017	Event	Bedding and Pot Plant Centre Open Evening – overview of project and trials completed so far on protected ornamentals (bedding).

		Demonstration of bedding trials hosted at Ivan Ambrose (trials relocated to BPPC for Open Evening).
22/06/2017	Event	G's NIAB Leafy Salads Open Day. Overview of project and trials work completed on salad propagation given by Chloe Whiteside and Sonia Newman. Demonstration of young lettuce in trays and crop grown on out in the field, propagated in various blends.
July 2017	Magazine	AHDB Grower magazine article covering the workshop at Vitacress Herbs (Spence Gunn, issue 235, page 20-21).
July 2017	Magazine	Commercial Greenhouse Grower article covering the potted herbs trial at the Vitacress workshop in June (July 2017 edition, page 4).
July 2017	Magazine	Commercial Greenhouse Grower article covering the soft fruit trial at the New Farm Produce workshop in April (July 2017 edition, page 11-13).
23-28/08/2017	Event	Portland Oregon ISHS symposium. Scientific paper delivered on the CP138 approach and outputs, by Barry Mulholland.
14/09/2017	Event	British Herbs Field Day – demonstration stand with herbs. Outlining project and progress, discussing current and future trials.
19/09/2017	Workshop	F P Matthews workshop (fruit trees). Overview of project and view of trials. Talks from Dr Brian Jackson (NCSU), John Adlam and Chris Nicholson. Machinery demo from Mechanical Botanical and nursery tour from Andrew Wright and Dale Swash.
01/11/2017	Event	Total Food Norwich. Overview of project given by Barry Mulholland.
07/12/2017	Workshop	Lowaters workshop (HNS). Overview of project and view of trials. Talks from Dr Gracie Barrett (Walberton Nursery) and Jude Bennison (ADAS). Machinery demo from Mechanical Botanical and nursery tour from Stephen Carr.
15/02/2018	Conference	Fruit Technical Seminar, Dundee. Overview of project and soft fruit trials given by Chloe Whiteside.
19/06/2018	Event	Bedding and Pot Plant Centre Open Evening – overview of project and trials completed so far on protected ornamentals (bedding). Demonstration of bedding trials hosted at Newey Roundstone (trials relocated to BPPC for Open Evening).
03/07/2018	Meeting	Growing Media Association meeting hosted at Darby Nursery Stock. Led by Neil Bragg and Steve Carter.
19/09/2018	Workshop	EU Plants workshop (soft fruit propagation), in association with FARMA/FRA. Overview of project and view of raspberry and strawberry trials. Presentation from Ruth D'urban-Jackson (ADAS) and nursery tour from Slavey Slavchev and Janet Allan (ADAS).
04/10/2018	Event	HortScience Live (South). Palmstead Nursery, Kent. Demonstration stand with HNS plants from the Boxworth trial. Outlining project and progress, discussing current and future trials and results in HNS.
09/10/2018	Workshop	Delflands Nursery workshop (veg propagation). Overview of project and view of cabbage prop trials. Presentations from Kirsty Wright (STC), and Andrew Taylor and Rosemary Collier (Warwick Crop Centre). Machinery demo from Mechanical Botanical and nursery tour from John Overvoorde.
15/10/2018	Magazine	AHDB Grower magazine article written by project team (Issue 242, page 20-21).
17/10/2018	Event	HortScience Live (North). Stockbridge Technology Centre. Demonstration stand with HNS plants from the Boxworth trial. Outlining project and progress, discussing current and future trials and results in HNS.
31/10/2018	Event	Alternative growing media for the production of ornamental crops. Newey Roundstone, Chichester. Pre-GroSouth event. Overview of project. Demonstration of autumn bedding trial at Newey Roundstone, along with physical properties of different blends and an update on bedding and HNS trials completed so far.
06/12/2018	Workshop	Wyevale Nursery workshop (hardy nursery stock). Overview of project and trials completed so far on HNS. Presentations from Jude Bennison, David Talbot, Dave Kaye and Ruth D'Urban Jackson (ADAS). Demonstration of RSGM HNS trials hosted at Darby Nursery Stock (some plants relocated to Wyevale for the workshop), as well as SceptrePlus trials and herbicide trials. Nursery tour from Steve Reed.

In 2018, the project team attended five industry events and hosted three standalone workshops. The industry events were; Fruit Technical Seminar (soft fruit), Bedding and Pot Plant Centre (BPPC) Open Evening (bedding), HortScience Live North and South (HNS and bedding) and the Pre-GroSouth event (HNS and bedding). At the HNS and bedding events, trial plants were demonstrated, along with growing media blends and raw materials, hand-outs and a project poster. Presentations were given at all events. All events were very well attended, and overall, approximately 320 growers and industry representatives were spoken to and informed of the project across the five events.

Independent workshops were held at EU Plants, Delfland Nurseries and Wyevale Nursery, and gave attendees the opportunity to view trials in progress. The events were well received, and attended by a total of 125 growers and industry representatives.

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.

In June 2016, a twitter account for CP138 was set-up (@GrowMediaADAS), 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 19 December 2018, the RSGM twitter account has 193 followers, which are a combination of growers, growing media manufacturers, horticultural companies and independents.

Industry awareness

The workshops have been extremely well received by the industry, and by attending other industry events as well, results from the project have been communicated to over **1245** members of the horticulture sector. As the project progresses, the number of attendees at workshops has grown, and the project is viewed by many as an important step in moving towards more responsibly sourced growing media in UK horticulture.

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. See above **Table 16**; **WP4** for details of activities.

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
11	Task 1.3.4 **M11** Conclusions	31/3/17	Yes	Completed in full and on time
12	Tasks 1.1-1.3 **M12** Create database of growing media	31/3/17	Yes	Completed in full and on time
13-28	All tasks on schedule to complete	30/10/19	Ongoing	On schedule to complete
29-30	All tasks on schedule to complete	31/12/19	Ongoing	On schedule to complete

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

EU Plants Raspberries

Table 1a. The five treatments used in the raspberry propagation trial.

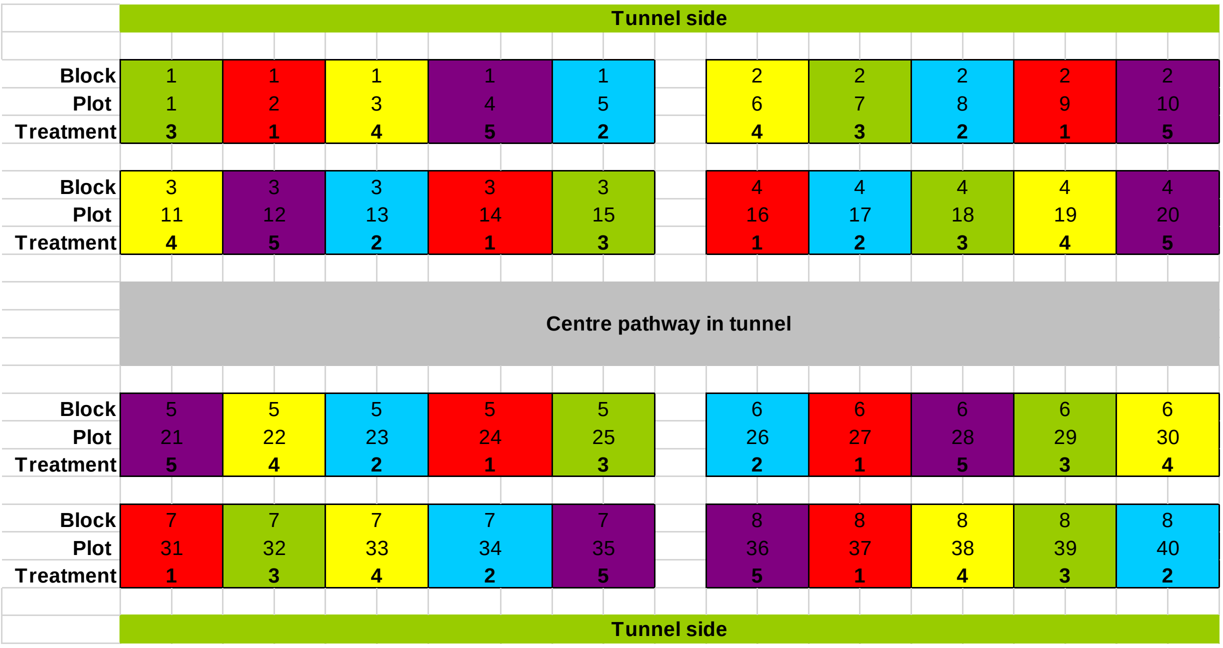
Trt no.	Growing media blend
1	Nursery 100% Coir standard
2	Coir-free supplied by one of the GMMs
3	Prototype 1
4	Prototype 2
5	Prototype 3

Table 1b. List of scores and definitions used to assess overall plant quality at transplanting.

Score	Definition
0	Dead
1	Very poor quality, yellowing foliage
2	Green but no new growth, small
3	Green with new leaves developing
4	Green with new growth
5	Good quality, plenty of new growth, marketable

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

Score	Definition
0	No change / dead
1	Callous formed
2	Finely rooted in up to 25% of cell
3	Rooting in 25 – 50% of cell
4	Rooting in 51 – 85% of cell
5	Fully rooted and ready for transplanting



Tunnel side

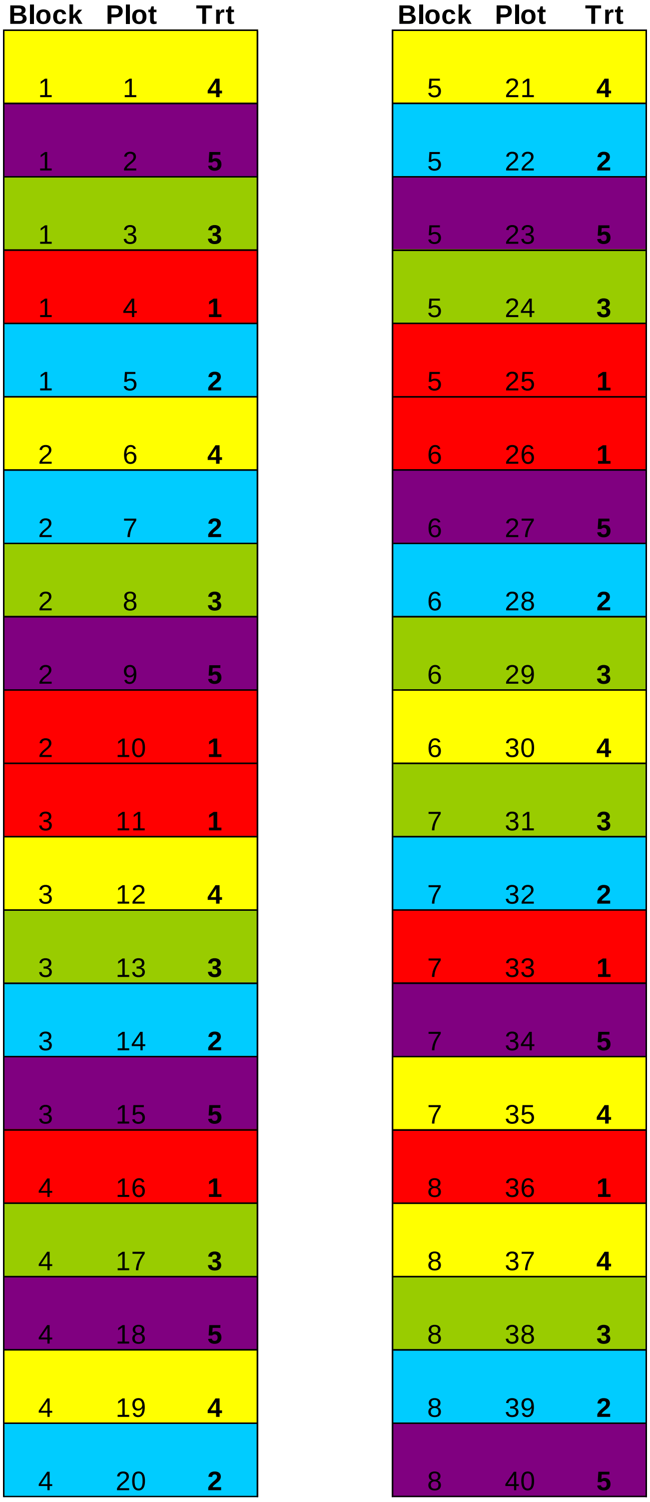
Block	1	1	1	1	1	2	2	2	2	2
Plot	1	2	3	4	5	6	7	8	9	10
Treatment	**3**	**1**	**4**	**5**	**2**	**4**	**3**	**2**	**1**	**5**
Block	3	3	3	3	3	4	4	4	4	4
Plot	11	12	13	14	15	16	17	18	19	20
Treatment	**4**	**5**	**2**	**1**	**3**	**1**	**2**	**3**	**4**	**5**

Centre pathway in tunnel

Block	5	5	5	5	5	6	6	6	6	6
Plot	21	22	23	24	25	26	27	28	29	30
Treatment	**5**	**4**	**2**	**1**	**3**	**2**	**1**	**5**	**3**	**4**
Block	7	7	7	7	7	8	8	8	8	8
Plot	31	32	33	34	35	36	37	38	39	40
Treatment	**1**	**3**	**4**	**2**	**5**	**5**	**1**	**4**	**3**	**2**

Tunnel side

Figure 1a. Trial plan for the raspberry propagation trial set-out within a covered polytunnel. Each plot contains 1 x 84-cell tray.



Block	Plot	Trt
1	1	**4**
1	2	**5**
1	3	**3**
1	4	**1**
1	5	**2**
2	6	**4**
2	7	**2**
2	8	**3**
2	9	**5**
2	10	**1**
3	11	**1**
3	12	**4**
3	13	**3**
3	14	**2**
3	15	**5**
4	16	**1**
4	17	**3**
4	18	**5**
4	19	**4**
4	20	**2**

Block	Plot	Trt
5	21	**4**
5	22	**2**
5	23	**5**
5	24	**3**
5	25	**1**
6	26	**1**
6	27	**5**
6	28	**2**
6	29	**3**
6	30	**4**
7	31	**3**
7	32	**2**
7	33	**1**
7	34	**5**
7	35	**4**
8	36	**1**
8	37	**4**
8	38	**3**
8	39	**2**
8	40	**5**

Figure 1b. Trial plan for the raspberry propagation trial set-out in rows within the field after transplant. Each plot contains 1 x 2 L pot holding two canes.

Table 1d: Treatment list for the raspberry propagation trial.

Trt No.	Product
1	Nursery control
2	GMM coir-free
3	Prototype 1
4	Prototype 2
5	Prototype 3

Appendix 2

EU Plants Strawberries

Table 2a. The five treatments used in the strawberry propagation trial.

Trt no.	Growing media blend
1	Nursery 100% Coir standard
2	Coir-free supplied by one of the GMMs
3	Prototype 1
4	Prototype 2
5	Prototype 3

Table 2b. List of scores and definitions used to assess overall plant quality at transplanting.

Score	Definition
0	Dead
1	Very poor quality, yellowing foliage
2	Green but no new growth, small
3	Green with new leaves developing
4	Green with new growth
5	Good quality, plenty of new growth, marketable

Table 2c. List of scores and definitions used to assess plant rooting in the cell at transplanting.

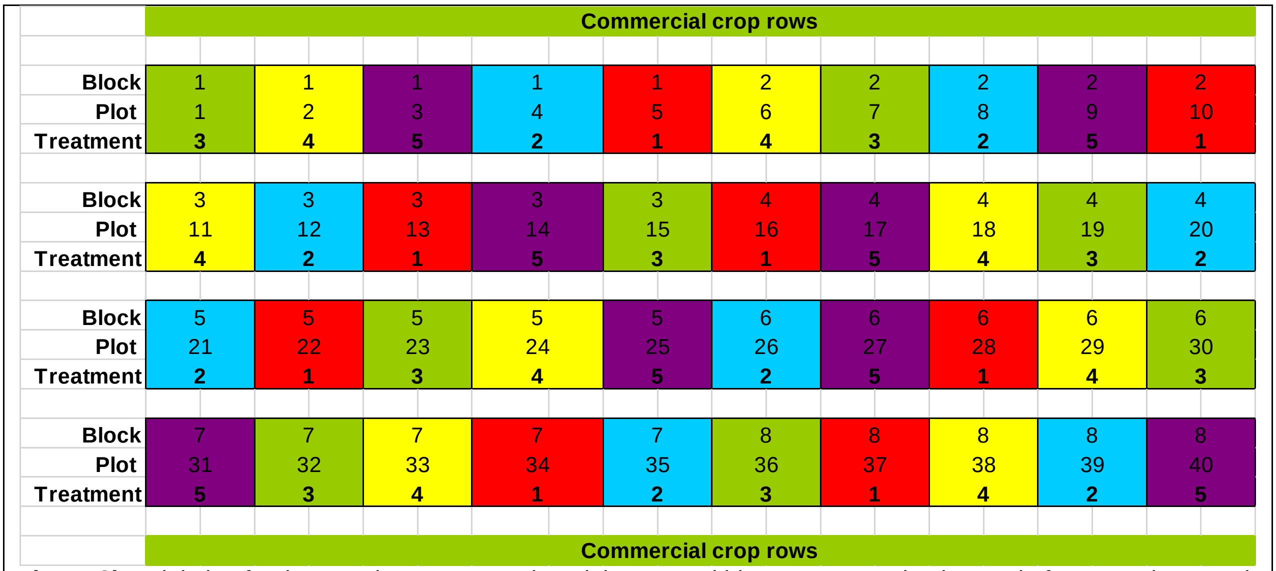
Score	Definition
0	No change / dead
1	Callous formed
2	Finely rooted in up to 25% of cell
3	Rooting in 25 – 50% of cell
4	Rooting in 51 – 85% of cell
5	Fully rooted and ready for transplanting

Tunnel side

Block	1	1	1	1	1		2	2	2	2	2
Plot	1	2	3	4	5		6	7	8	9	10
Treatment	**1**	**2**	**3**	**5**	**4**		**5**	**2**	**1**	**4**	**3**
Block	3	3	3	3	3		4	4	4	4	4
Plot	11	12	13	14	15		16	17	18	19	20
Treatment	**2**	**3**	**1**	**4**	**5**		**3**	**5**	**4**	**2**	**1**
Block	5	5	5	5	5		6	6	6	6	6
Plot	21	22	23	24	25		26	27	28	29	30
Treatment	**1**	**4**	**5**	**2**	**3**		**1**	**3**	**2**	**5**	**4**
Block	7	7	7	7	7		8	8	8	8	8
Plot	31	32	33	34	35		36	37	38	39	40
Treatment	**4**	**5**	**2**	**3**	**1**		**2**	**4**	**3**	**1**	**5**

Tunnel side

Figure 2a. Trial plan for the strawberry propagation trial set-out within an uncovered polytunnel. Each plot contains 1 x 84-cell tray.



Commercial crop rows

Block	1	1	1	1	1	2	2	2	2	2
Plot	1	2	3	4	5	6	7	8	9	10
Treatment	**3**	**4**	**5**	**2**	**1**	**4**	**3**	**2**	**5**	**1**
Block	3	3	3	3	3	4	4	4	4	4
Plot	11	12	13	14	15	16	17	18	19	20
Treatment	**4**	**2**	**1**	**5**	**3**	**1**	**5**	**4**	**3**	**2**
Block	5	5	5	5	5	6	6	6	6	6
Plot	21	22	23	24	25	26	27	28	29	30
Treatment	**2**	**1**	**3**	**4**	**5**	**2**	**5**	**1**	**4**	**3**
Block	7	7	7	7	7	8	8	8	8	8
Plot	31	32	33	34	35	36	37	38	39	40
Treatment	**5**	**3**	**4**	**1**	**2**	**3**	**1**	**4**	**2**	**5**

Commercial crop rows

Figure 2b. Trial plan for the strawberry propagation trial set-out within an uncovered polytunnel after transplant. Each plot contains 1 x 18-cell tray.

Table 2d: Treatment list for the strawberry propagation trial.

Trt No.	Product
1	Nursery control
2	GMM coir-free
3	Prototype 1
4	Prototype 2
5	Prototype 3

Appendix 3
F P Matthews Top Fruit

Table 3a. The four treatments used in the apple and cherry trial.

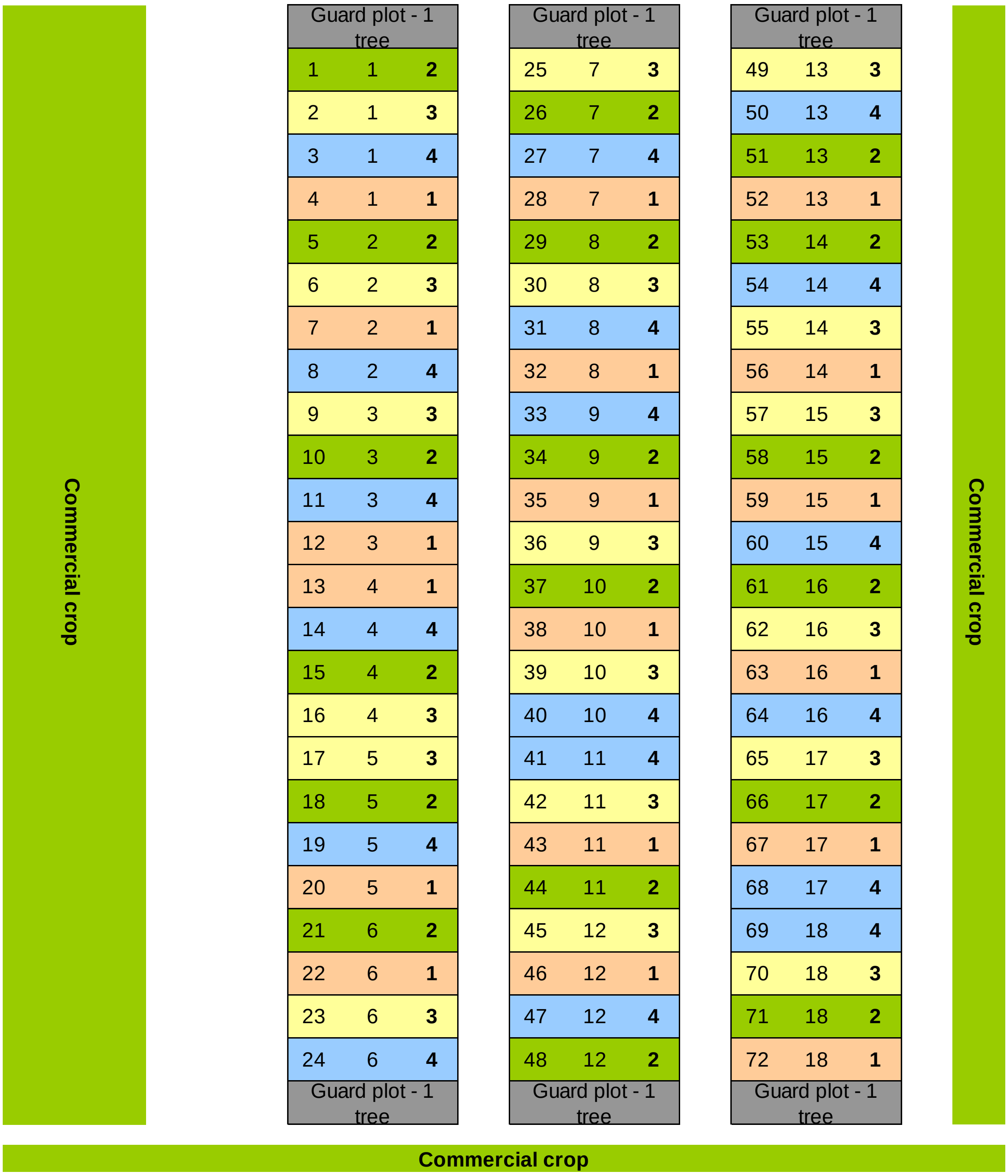
Trt no.	Growing media blend
1	Nursery 100% Peat-free standard
2	Prototype 1
3	Prototype 2
4	Prototype 3

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

Score	Definition
0	Dead
1	Very poor quality, yellowing foliage
2	Poor quality, small
3	Good quality, healthy foliage
4	Very good quality, healthy foliage, some new growth
5	Excellent quality, healthy foliage, plenty of new growth

Table 3c. List of scores and definitions used to assess plant rooting in the pot.

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



Commercial crop										Commercial crop
	Guard plot - 1 tree			Guard plot - 1 tree			Guard plot - 1 tree			
	1	1	**2**	25	7	**3**	49	13	**3**	
	2	1	**3**	26	7	**2**	50	13	**4**	
	3	1	**4**	27	7	**4**	51	13	**2**	
	4	1	**1**	28	7	**1**	52	13	**1**	
	5	2	**2**	29	8	**2**	53	14	**2**	
	6	2	**3**	30	8	**3**	54	14	**4**	
	7	2	**1**	31	8	**4**	55	14	**3**	
	8	2	**4**	32	8	**1**	56	14	**1**	
	9	3	**3**	33	9	**4**	57	15	**3**	
	10	3	**2**	34	9	**2**	58	15	**2**	
	11	3	**4**	35	9	**1**	59	15	**1**	
	12	3	**1**	36	9	**3**	60	15	**4**	
	13	4	**1**	37	10	**2**	61	16	**2**	
	14	4	**4**	38	10	**1**	62	16	**3**	
	15	4	**2**	39	10	**3**	63	16	**1**	
	16	4	**3**	40	10	**4**	64	16	**4**	
	17	5	**3**	41	11	**4**	65	17	**3**	
	18	5	**2**	42	11	**3**	66	17	**2**	
	19	5	**4**	43	11	**1**	67	17	**1**	
	20	5	**1**	44	11	**2**	68	17	**4**	
	21	6	**2**	45	12	**3**	69	18	**4**	
	22	6	**1**	46	12	**1**	70	18	**3**	
	23	6	**3**	47	12	**4**	71	18	**2**	
	24	6	**4**	48	12	**2**	72	18	**1**	
	Guard plot - 1 tree			Guard plot - 1 tree			Guard plot - 1 tree			

Commercial crop

Trt No.	Product
1	Nursery standard
2	Prototype 1
3	Prototype 2
4	Prototype 3

Figure 3a. Trial plan for fruit trees set out on gravel beds outside. Each plot contains 2 x 12 L pots.

Appendix 4

Lowaters Nurseries Hardy Nursery Stock

Table 4a. The four treatments used in the hardy nursery stock trials.

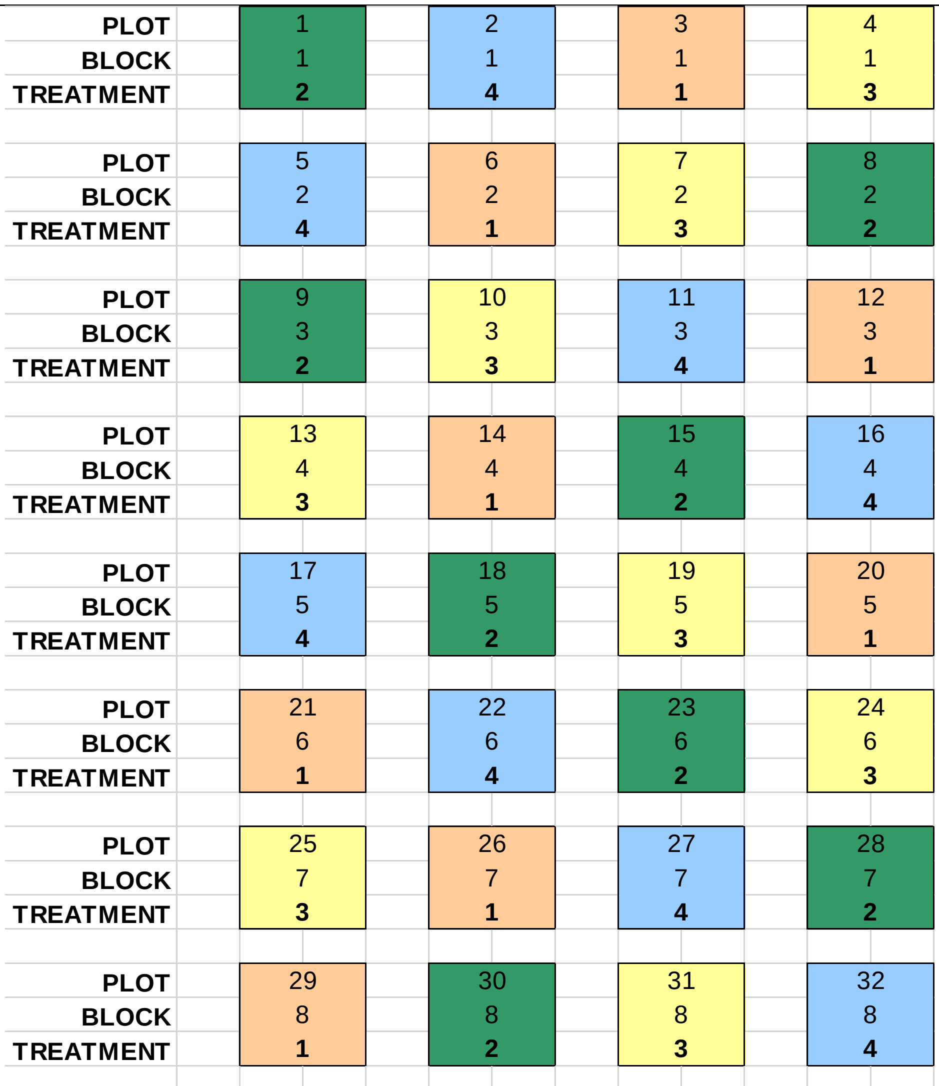
Trt no.	Growing media blend
1	Nursery Peat-free standard
2	Prototype 1
3	Prototype 2
4	Prototype 3

Table 4b. List of scores and definitions used to assess overall plant quality.

Score	Definition
0	Dead
1	Very poor quality, yellowing foliage
2	Poor quality, small
3	Good quality, healthy foliage
4	Very good quality, healthy foliage, some new growth
5	Excellent quality, healthy foliage, plenty of new growth

Table 4c. List of scores and definitions used to assess plant rooting in the pot.

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



PLOT	1	2	3	4
BLOCK	1	1	1	1
TREATMENT	**2**	**4**	**1**	**3**
PLOT	5	6	7	8
BLOCK	2	2	2	2
TREATMENT	**4**	**1**	**3**	**2**
PLOT	9	10	11	12
BLOCK	3	3	3	3
TREATMENT	**2**	**3**	**4**	**1**
PLOT	13	14	15	16
BLOCK	4	4	4	4
TREATMENT	**3**	**1**	**2**	**4**
PLOT	17	18	19	20
BLOCK	5	5	5	5
TREATMENT	**4**	**2**	**3**	**1**
PLOT	21	22	23	24
BLOCK	6	6	6	6
TREATMENT	**1**	**4**	**2**	**3**
PLOT	25	26	27	28
BLOCK	7	7	7	7
TREATMENT	**3**	**1**	**4**	**2**
PLOT	29	30	31	32
BLOCK	8	8	8	8
TREATMENT	**1**	**2**	**3**	**4**

Trt No.	Treatment
1	Nursery control
2	Prototype 1
3	Prototype 2
4	Prototype 3

Figure 4a. Trial plan for HNS plants set out on the floor under glass and polythene (Lowaters). Each plot contains 5 x 2 L pots.

Appendix 5

Delfland Nurseries Vegetable propagation

Table 5a. The six treatments used in the vegetable propagation trials.

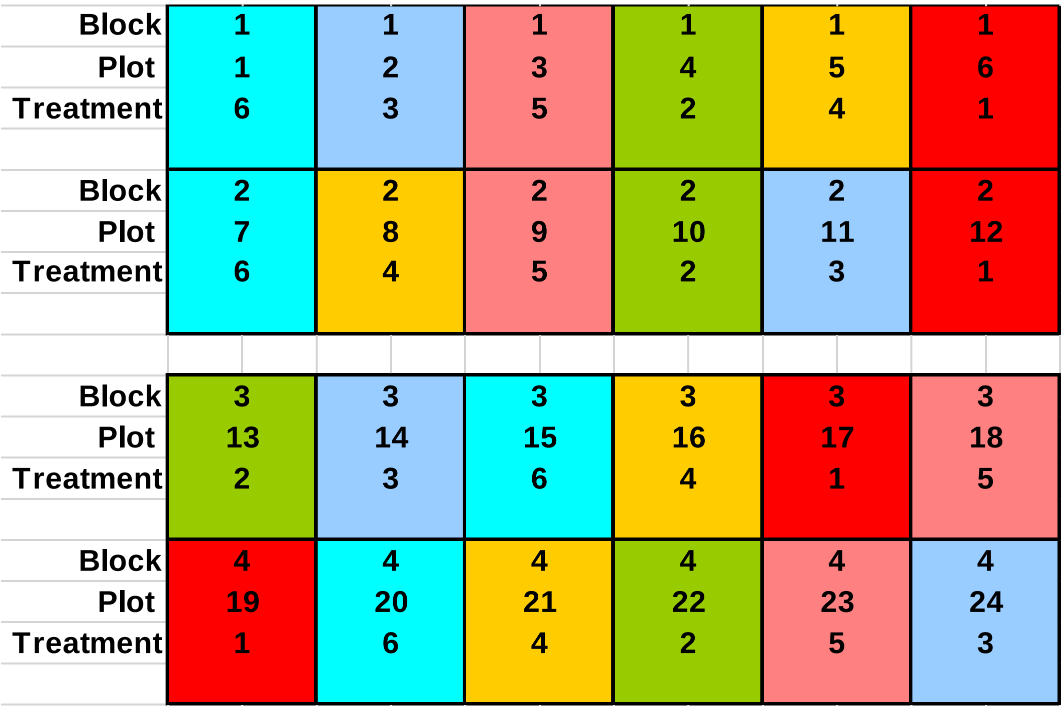
Trt no.	Growing media blend
1	Nursery Peat-reduced standard
2	Prototype 1 (1st Gen)
3	Prototype 4 (2nd Gen)
4	Prototype 5 (2nd Gen)
5	Prototype 6 (2nd Gen)
6	Prototype 7 (2nd Gen)

Table 5b. List of scores and definitions used to assess overall plant quality.

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

Table 5c. 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



Block	1	1	1	1	1	1
Plot	1	2	3	4	5	6
Treatment	6	3	5	2	4	1
Block	2	2	2	2	2	2
Plot	7	8	9	10	11	12
Treatment	6	4	5	2	3	1
Block	3	3	3	3	3	3
Plot	13	14	15	16	17	18
Treatment	2	3	6	4	1	5
Block	4	4	4	4	4	4
Plot	19	20	21	22	23	24
Treatment	1	6	4	2	5	3

Figure 5a. Trial plan for Chinese cabbage plants set out under glass at Delflands Nursery. Each plot contains 1 x 345-cell tray.

Block	1	1	1	1	1	1
Plot	1	2	3	4	5	6
Treatment	4	2	3	5	1	6
Block	2	2	2	2	2	2
Plot	7	8	9	10	11	12
Treatment	6	4	3	2	5	1
Block	3	3	3	3	3	3
Plot	13	14	15	16	17	18
Treatment	4	3	1	2	5	6
Block	4	4	4	4	4	4
Plot	19	20	21	22	23	24
Treatment	3	2	4	6	1	5

Figure 5b. Trial plan for Spring cabbage plants set out under glass at Delflands Nursery. Each plot contains 1 x 345-cell tray.

Table 5d: Treatment list for Chinese and Spring cabbage trials.

Trt No.	Treatment
1	Nursery control
2	Prototype 1
3	Prototype 4
4	Prototype 5
5	Prototype 6
6	Prototype 7

Appendix 6

Newey Roundstone Bedding

Table 6a. The six treatments used in the pack and pot bedding trials.

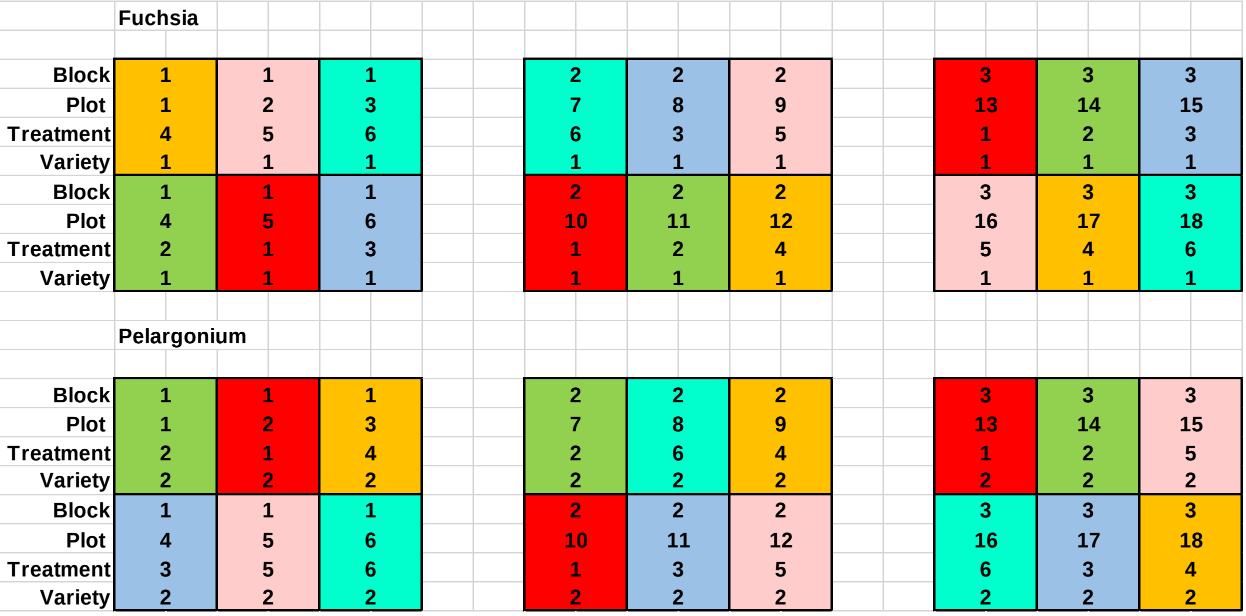
Trt no.	Growing media blend
1	Nursery Peat-reduced standard
2	Prototype 3 (1st Gen)
3	Prototype 4 (2nd Gen)
4	Prototype 5 (2nd Gen)
5	Prototype 6 (2nd Gen)
6	Prototype 7 (2nd Gen)

Table 6b. List of scores and definitions used to assess overall plant quality for marketability.

Score	Definition
0	Dead
1	Very poor quality, yellowing foliage
2	Poor quality, small
3	Good quality, healthy foliage
4	Very good quality, healthy foliage, some new growth
5	Excellent quality, healthy foliage, plenty of new growth

Table 6c. List of scores and definitions used to assess plant rooting in the cell/pot.

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



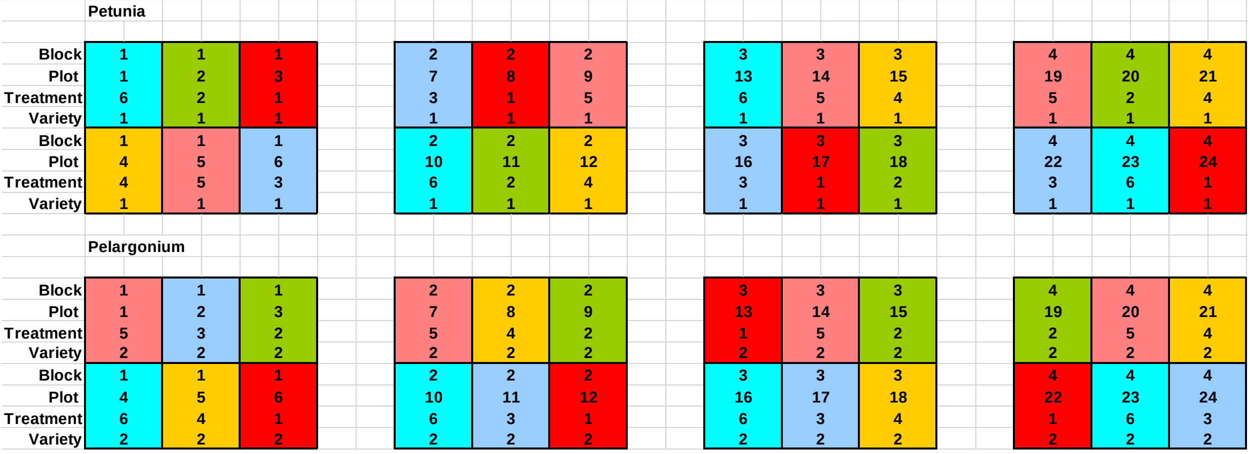
Fuchsia

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

Pelargonium

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

Figure 6a. Trial plan for the summer pot bedding trials set out under glass. Each plot contains 3 x 10.5 cm pots.



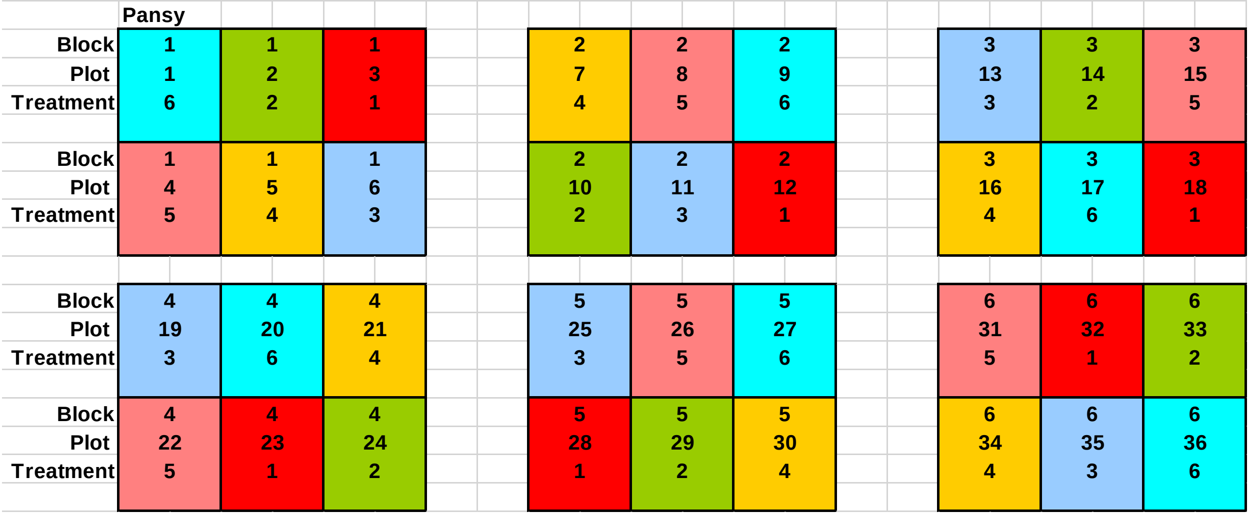
Petunia

Block	1	1	1	2	2	2	3	3	3	4	4	4
Plot	1	2	3	7	8	9	13	14	15	19	20	21
Treatment	6	2	1	3	1	5	6	5	4	5	2	4
Variety	1	1	1	1	1	1	1	1	1	1	1	1
Block	1	1	1	2	2	2	3	3	3	4	4	4
Plot	4	5	6	10	11	12	16	17	18	22	23	24
Treatment	4	5	3	6	2	4	3	1	2	3	6	1
Variety	1	1	1	1	1	1	1	1	1	1	1	1

Pelargonium

Block	1	1	1	2	2	2	3	3	3	4	4	4
Plot	1	2	3	7	8	9	13	14	15	19	20	21
Treatment	5	3	2	5	4	2	1	5	2	2	5	4
Variety	2	2	2	2	2	2	2	2	2	2	2	2
Block	1	1	1	2	2	2	3	3	3	4	4	4
Plot	4	5	6	10	11	12	16	17	18	22	23	24
Treatment	6	4	1	6	3	1	6	3	4	1	6	3
Variety	2	2	2	2	2	2	2	2	2	2	2	2

Figure 6b. Trial plan for the summer pack bedding trials set out under glass. Each plot contains 2 x 10-cell packs.



Pansy

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

Figure 6c. Trial plan for the autumn pack bedding trial set out under glass. Each plot contains 2 x 10-cell packs.

Table 6d. Treatment list for the summer and autumn pot and pack bedding trials.

Trt No.	Treatment
1	Nursery control
2	Prototype 3
3	Prototype 4
4	Prototype 5
5	Prototype 6
6	Prototype 7

Appendix 7

Experimental trials

Table 7a. Experimental treatment list for the prototype blend trials.

Trt no.	Growing media blend	Blend components	Irrigation treatment	Target N concentration
1	Blend 1 - Peat standard	N/A	Low	100 ppm N
2	Blend 2	M1 100%	Low	100 ppm N
3	Blend 3	M2 33% / M1 67%	Low	100 ppm N
4	Blend 4	M3 33% / M1 67%	Low	100 ppm N
5	Blend 5	M2 100%	Low	100 ppm N
6	Blend 6	M2 67% / M1 33%	Low	100 ppm N
7	Blend 7	M3 33% / M2 67%	Low	100 ppm N
8	Blend 8	M3 100%	Low	100 ppm N
9	Blend 9	M3 67% / M1 33%	Low	100 ppm N
10	Blend 10	M3 67% / M2 33%	Low	100 ppm N
11	Blend 11	M4 33% / M1 67%	Low	100 ppm N
12	Blend 12	M4 100%	Low	100 ppm N
13	Blend 13	M4 67% / M1 33%	Low	100 ppm N
14	Blend 14	M2 33% / M4 67%	Low	100 ppm N
15	Blend 15	M3 33% / M4 67%	Low	100 ppm N
16	Blend 16	M2 67% / M4 33%	Low	100 ppm N
17	Blend 17	M3 67% / M4 33%	Low	100 ppm N
18	Blend 18	M3 33% / M4 33% / M1 33%	Low	100 ppm N
19	Blend 19	M3 33% / M2 33% / M4 33%	Low	100 ppm N

Table 7b. Measured physical properties for the experimental prototype blends.

Growing media blend	AFP	D_b	AW
Blend 1 - Peat standard	7.83	0.174	44.94
Blend 2	44.76	0.083	27.23
Blend 3	26.89	0.137	28.03
Blend 4	30.64	0.077	27.00
Blend 5	16.23	0.203	31.16
Blend 6	23.33	0.168	31.06
Blend 7	21.39	0.171	31.17
Blend 8	20.63	0.120	52.38
Blend 9	23.35	0.083	33.31
Blend 10	27.47	0.132	30.53
Blend 11	29.11	0.114	27.12
Blend 12	12.49	0.183	27.65
Blend 13	18.80	0.142	28.31
Blend 14	13.74	0.188	29.57
Blend 15	20.85	0.144	26.09
Blend 16	17.47	0.183	32.32
Blend 17	22.09	0.111	30.13
Blend 18	19.07	0.115	28.50
Blend 19	18.40	0.167	31.06

Table 7c. Levels of nutrients delivered to the trial when fertilisers 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)
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

Appendix 8

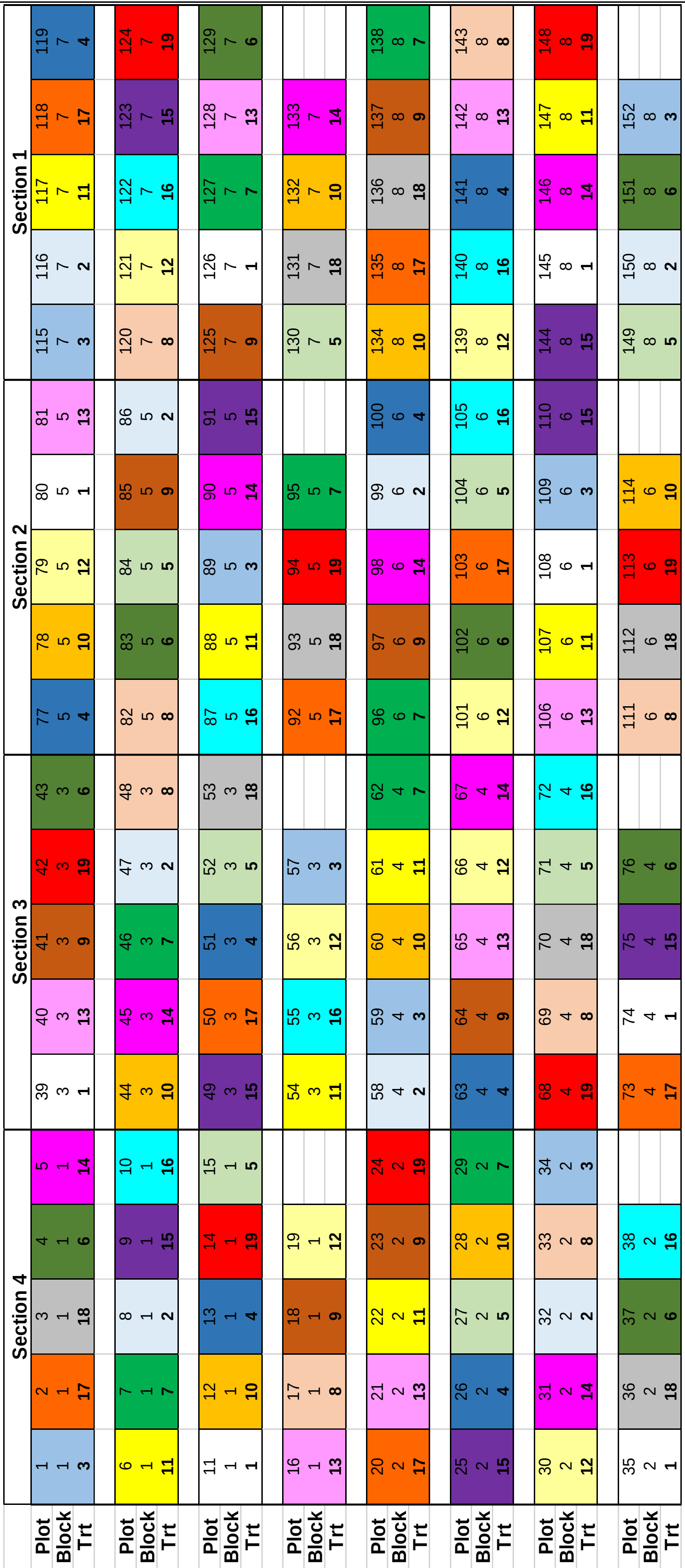
Experimental pot chrysanthemum trial

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

Score	Definition
0	Dead
1	Very poor quality, yellowing foliage
2	Poor quality, small
3	Good quality, healthy foliage
4	Very good quality, healthy foliage, some new growth
5	Excellent quality, healthy foliage, plenty of new growth

Table 8b. List of scores and definitions used to assess plant rooting in the pot.

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



	Section 4					Section 3					Section 2					Section 1				
Plot	1	2	3	4	5	39	40	41	42	43	77	78	79	80	81	115	116	117	118	119
Block	1	1	1	1	1	3	3	3	3	3	5	5	5	5	5	7	7	7	7	7
Trt	3	17	18	6	14	1	13	9	19	6	4	10	12	1	13	3	2	11	17	4
Plot	6	7	8	9	10	44	45	46	47	48	82	83	84	85	86	120	121	122	123	124
Block	1	1	1	1	1	3	3	3	3	3	5	5	5	5	5	7	7	7	7	7
Trt	11	7	2	15	16	10	14	7	2	8	8	6	5	9	2	8	12	16	15	19
Plot	11	12	13	14	15	49	50	51	52	53	87	88	89	90	91	125	126	127	128	129
Block	1	1	1	1	1	3	3	3	3	3	5	5	5	5	5	7	7	7	7	7
Trt	1	10	4	19	5	15	17	4	5	18	16	11	3	14	15	9	1	7	13	6
Plot	16	17	18	19		54	55	56	57		92	93	94	95		130	131	132	133	
Block	1	1	1	1		3	3	3	3		5	5	5	5		7	7	7	7	
Trt	13	8	9	12		11	16	12	3		17	18	19	7		5	18	10	14	
Plot	20	21	22	23	24	58	59	60	61	62	96	97	98	99	100	134	135	136	137	138
Block	2	2	2	2	2	4	4	4	4	4	6	6	6	6	6	8	8	8	8	8
Trt	17	13	11	9	19	2	3	10	11	7	7	9	14	2	4	10	17	18	9	7
Plot	25	26	27	28	29	63	64	65	66	67	101	102	103	104	105	139	140	141	142	143
Block	2	2	2	2	2	4	4	4	4	4	6	6	6	6	6	8	8	8	8	8
Trt	15	4	5	10	7	4	9	13	12	14	12	6	17	5	16	12	16	4	13	8
Plot	30	31	32	33	34	68	69	70	71	72	106	107	108	109	110	144	145	146	147	148
Block	2	2	2	2	2	4	4	4	4	4	6	6	6	6	6	8	8	8	8	8
Trt	12	14	2	8	3	19	8	18	5	16	13	11	1	3	15	15	1	14	11	19
Plot	35	36	37	38		73	74	75	76		111	112	113	114		149	150	151	152	
Block	2	2	2	2		4	4	4	4		6	6	6	6		8	8	8	8	
Trt	1	18	6	16		17	1	15	6		8	18	19	10		5	2	6	3	

Treatment no.	Blend components
1	Peat control
2	M1 100%
3	M2 33% / M1 66%
4	M3 33% / M1 66%
5	M2 100%
6	M2 66% / M1 33%
7	M3 33% / M2 66%
8	M3 100%
9	M3 66% / M1 33%
10	M3 66% / M2 33%
11	M4 33% / M1 66%
12	M4 100%
13	M4 66% / M1 33%
14	M2 33% / M4 66%
15	M3 33% / M4 66%
16	M2 66% / M4 33%
17	M3 66% / M4 33%
18	M3 33% / M4 33% / M1 33%
19	M3 33% / M2 33% / M4 33%

Figure 8a. Trial plan for pot chrysanthemum set out on an ebb and flood bench split into four sections separated by Perspex sheeting.

Appendix 9

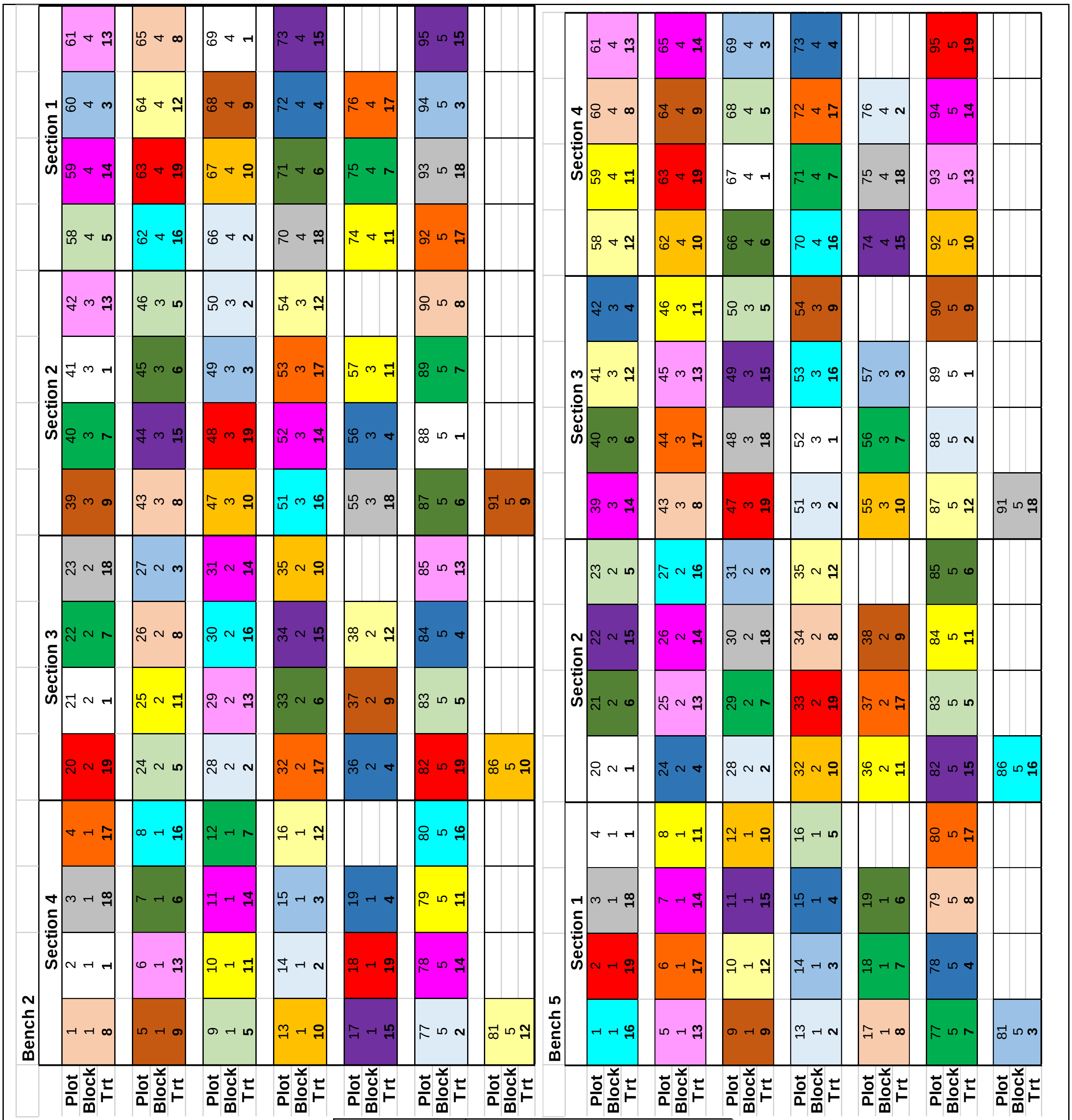
Experimental HNS trial

Table 9a. List of scores and definitions used to assess overall plant quality during the trial.

Score	Definition
0	Dead
1	Very poor quality, yellowing foliage
2	Poor quality, small
3	Good quality, healthy foliage
4	Very good quality, healthy foliage, some new growth
5	Excellent quality, healthy foliage, plenty of new growth

Table 9b. List of scores and definitions used to assess plant rooting at the end of the trial.

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



Bench 2	Section 4				Section 3				Section 2				Section 1			
Plot	1	2	3	4	20	21	22	23	39	40	41	42	58	59	60	61
Block	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4
Trt	8	1	18	17	19	1	7	18	9	7	1	13	5	14	3	13
Plot	5	6	7	8	24	25	26	27	43	44	45	46	62	63	64	65
Block	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4
Trt	9	13	6	16	5	11	8	3	8	15	6	5	16	19	12	8
Plot	9	10	11	12	28	29	30	31	47	48	49	50	66	67	68	69
Block	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4
Trt	5	11	14	7	2	13	16	14	10	19	3	2	2	10	9	1
Plot	13	14	15	16	32	33	34	35	51	52	53	54	70	71	72	73
Block	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4
Trt	10	2	3	12	17	6	15	10	16	14	17	12	18	6	4	15
Plot	17	18	19		36	37	38		55	56	57		74	75	76	
Block	1	1	1		2	2	2		3	3	3		4	4	4	
Trt	15	19	4		4	9	12		18	4	11		11	7	17	
Plot	77	78	79	80	82	83	84	85	87	88	89	90	92	93	94	95
Block	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Trt	2	14	11	16	19	5	4	13	6	1	7	8	17	18	3	15
Plot	81				86				91							
Block	5				5				5							
Trt	12				10				9							

Bench 5	Section 1				Section 2				Section 3				Section 4			
Plot	1	2	3	4	20	21	22	23	39	40	41	42	58	59	60	61
Block	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4
Trt	16	19	18	1	1	6	15	5	14	6	12	4	12	11	8	13
Plot	5	6	7	8	24	25	26	27	43	44	45	46	62	63	64	65
Block	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4
Trt	13	17	14	11	4	13	14	16	8	17	13	11	10	19	9	14
Plot	9	10	11	12	28	29	30	31	47	48	49	50	66	67	68	69
Block	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4
Trt	9	12	15	10	2	7	18	3	19	18	15	5	6	1	5	3
Plot	13	14	15	16	32	33	34	35	51	52	53	54	70	71	72	73
Block	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4
Trt	2	3	4	5	10	19	8	12	2	1	16	9	16	7	17	4
Plot	17	18	19		36	37	38		55	56	57		74	75	76	
Block	1	1	1		2	2	2		3	3	3		4	4	4	
Trt	8	7	6		11	17	9		10	7	3		15	18	2	
Plot	77	78	79	80	82	83	84	85	87	88	89	90	92	93	94	95
Block	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Trt	7	4	8	17	15	5	11	6	12	2	1	9	10	13	14	19
Plot	81				86				91							
Block	5				5				5							
Trt	3				16				18							

Treatment no.	Blend components
1	Peat control
2	M1 100%
3	M2 33% / M1 66%
4	M3 33% / M1 66%
5	M2 100%
6	M2 66% / M1 33%
7	M3 33% / M2 66%
8	M3 100%
9	M3 66% / M1 33%
10	M3 66% / M2 33%
11	M4 33% / M1 66%
12	M4 100%
13	M4 66% / M1 33%
14	M2 33% / M4 66%
15	M3 33% / M4 66%
16	M2 66% / M4 33%
17	M3 66% / M4 33%
18	M3 33% / M4 33% / M1 33%
19	M3 33% / M2 33% / M4 33%

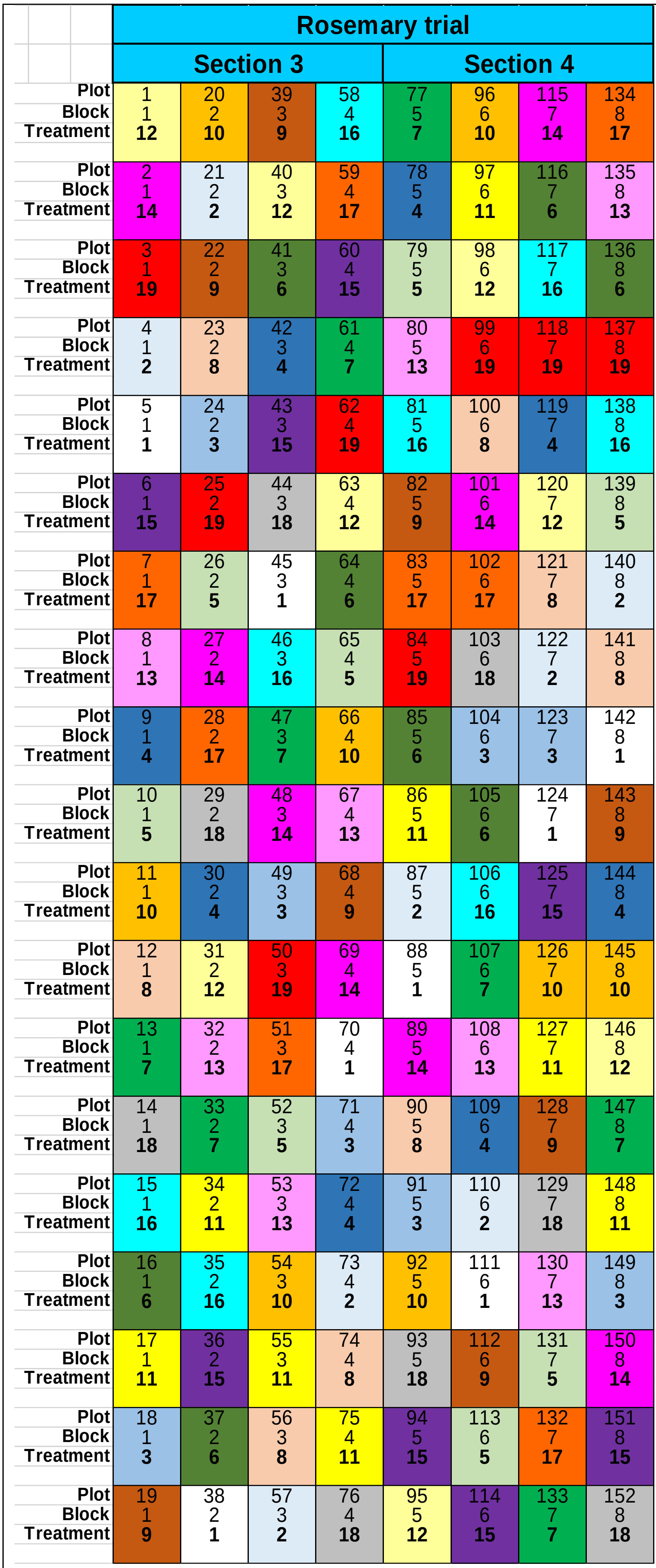
Figure 9a. Trial plan for *Griselinia* (left) and viburnum (right) set out on an overhead sprinkler bench split into four sections separated by Perspex sheeting.

Appendix 10

Experimental Herbs trial

	Basil trial								Coriander trial							
	Section 1				Section 2				Section 3				Section 4			
Plot	1	20	39	58	77	96	115	134	1	20	39	58	77	96	115	134
Block	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Treatment	**5**	**7**	**10**	**4**	**14**	**2**	**11**	**13**	**13**	**15**	**18**	**14**	**6**	**3**	**2**	**9**
Plot	2	21	40	59	78	97	116	135	2	21	40	59	78	97	116	135
Block	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Treatment	**13**	**19**	**12**	**9**	**7**	**12**	**9**	**11**	**8**	**6**	**9**	**8**	**9**	**5**	**9**	**18**
Plot	3	22	41	60	79	98	117	136	3	22	41	60	79	98	117	136
Block	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Treatment	**7**	**18**	**11**	**10**	**5**	**13**	**3**	**9**	**12**	**8**	**5**	**17**	**17**	**18**	**11**	**10**
Plot	4	23	42	61	80	99	118	137	4	23	42	61	80	99	118	137
Block	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Treatment	**6**	**8**	**7**	**6**	**18**	**11**	**15**	**3**	**11**	**3**	**2**	**13**	**3**	**8**	**19**	**15**
Plot	5	24	43	62	81	100	119	138	5	24	43	62	81	100	119	138
Block	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Treatment	**9**	**4**	**5**	**17**	**1**	**15**	**17**	**10**	**6**	**7**	**6**	**6**	**12**	**6**	**6**	**14**
Plot	6	25	44	63	82	101	120	139	6	25	44	63	82	101	120	139
Block	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Treatment	**14**	**11**	**14**	**13**	**11**	**6**	**8**	**7**	**10**	**12**	**13**	**1**	**18**	**7**	**8**	**2**
Plot	7	26	45	64	83	102	121	140	7	26	45	64	83	102	121	140
Block	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Treatment	**19**	**17**	**17**	**12**	**6**	**16**	**7**	**18**	**19**	**1**	**3**	**7**	**14**	**16**	**12**	**1**
Plot	8	27	46	65	84	103	122	141	8	27	46	65	84	103	122	141
Block	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Treatment	**3**	**9**	**8**	**5**	**19**	**10**	**13**	**12**	**14**	**16**	**7**	**19**	**13**	**14**	**14**	**6**
Plot	9	28	47	66	85	104	123	142	9	28	47	66	85	104	123	142
Block	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Treatment	**15**	**3**	**18**	**18**	**8**	**8**	**18**	**5**	**3**	**17**	**16**	**4**	**15**	**17**	**1**	**16**
Plot	10	29	48	67	86	105	124	143	10	29	48	67	86	105	124	143
Block	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Treatment	**12**	**13**	**13**	**7**	**3**	**17**	**10**	**15**	**18**	**19**	**17**	**15**	**4**	**9**	**10**	**4**
Plot	11	30	49	68	87	106	125	144	11	30	49	68	87	106	125	144
Block	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Treatment	**17**	**14**	**2**	**14**	**9**	**1**	**19**	**14**	**7**	**9**	**14**	**3**	**19**	**11**	**15**	**8**
Plot	12	31	50	69	88	107	126	145	12	31	50	69	88	107	126	145
Block	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Treatment	**10**	**1**	**16**	**16**	**15**	**18**	**1**	**2**	**4**	**13**	**1**	**2**	**7**	**12**	**7**	**17**
Plot	13	32	51	70	89	108	127	146	13	32	51	70	89	108	127	146
Block	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Treatment	**1**	**15**	**3**	**15**	**17**	**9**	**5**	**19**	**1**	**5**	**12**	**16**	**1**	**4**	**16**	**3**
Plot	14	33	52	71	90	109	128	147	14	33	52	71	90	109	128	147
Block	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Treatment	**2**	**12**	**19**	**19**	**2**	**19**	**14**	**17**	**15**	**11**	**8**	**18**	**5**	**15**	**5**	**7**
Plot	15	34	53	72	91	110	129	148	15	34	53	72	91	110	129	148
Block	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Treatment	**16**	**16**	**4**	**2**	**12**	**14**	**6**	**6**	**2**	**4**	**15**	**11**	**10**	**10**	**4**	**5**
Plot	16	35	54	73	92	111	130	149	16	35	54	73	92	111	130	149
Block	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Treatment	**18**	**5**	**9**	**8**	**16**	**5**	**2**	**8**	**16**	**18**	**11**	**12**	**2**	**19**	**3**	**19**
Plot	17	36	55	74	93	112	131	150	17	36	55	74	93	112	131	150
Block	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Treatment	**4**	**6**	**6**	**11**	**4**	**3**	**4**	**1**	**17**	**14**	**10**	**9**	**8**	**13**	**13**	**12**
Plot	18	37	56	75	94	113	132	151	18	37	56	75	94	113	132	151
Block	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Treatment	**8**	**10**	**15**	**3**	**13**	**7**	**12**	**4**	**5**	**2**	**4**	**5**	**16**	**1**	**18**	**11**
Plot	19	38	57	76	95	114	133	152	19	38	57	76	95	114	133	152
Block	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Treatment	**11**	**2**	**1**	**1**	**10**	**4**	**16**	**16**	**9**	**10**	**19**	**10**	**11**	**2**	**17**	**13**

Figure 10a. Trial plan for basil (left) and coriander (right) set out on an ebb and flood bench split into four sections separated by Perspex sheeting.



	Rosemary trial							
	Section 3				Section 4			
Plot Block Treatment	1 1 **12**	20 2 **10**	39 3 **9**	58 4 **16**	77 5 **7**	96 6 **10**	115 7 **14**	134 8 **17**
Plot Block Treatment	2 1 **14**	21 2 **2**	40 3 **12**	59 4 **17**	78 5 **4**	97 6 **11**	116 7 **6**	135 8 **13**
Plot Block Treatment	3 1 **19**	22 2 **9**	41 3 **6**	60 4 **15**	79 5 **5**	98 6 **12**	117 7 **16**	136 8 **6**
Plot Block Treatment	4 1 **2**	23 2 **8**	42 3 **4**	61 4 **7**	80 5 **13**	99 6 **19**	118 7 **19**	137 8 **19**
Plot Block Treatment	5 1 **1**	24 2 **3**	43 3 **15**	62 4 **19**	81 5 **16**	100 6 **8**	119 7 **4**	138 8 **16**
Plot Block Treatment	6 1 **15**	25 2 **19**	44 3 **18**	63 4 **12**	82 5 **9**	101 6 **14**	120 7 **12**	139 8 **5**
Plot Block Treatment	7 1 **17**	26 2 **5**	45 3 **1**	64 4 **6**	83 5 **17**	102 6 **17**	121 7 **8**	140 8 **2**
Plot Block Treatment	8 1 **13**	27 2 **14**	46 3 **16**	65 4 **5**	84 5 **19**	103 6 **18**	122 7 **2**	141 8 **8**
Plot Block Treatment	9 1 **4**	28 2 **17**	47 3 **7**	66 4 **10**	85 5 **6**	104 6 **3**	123 7 **3**	142 8 **1**
Plot Block Treatment	10 1 **5**	29 2 **18**	48 3 **14**	67 4 **13**	86 5 **11**	105 6 **6**	124 7 **1**	143 8 **9**
Plot Block Treatment	11 1 **10**	30 2 **4**	49 3 **3**	68 4 **9**	87 5 **2**	106 6 **16**	125 7 **15**	144 8 **4**
Plot Block Treatment	12 1 **8**	31 2 **12**	50 3 **19**	69 4 **14**	88 5 **1**	107 6 **7**	126 7 **10**	145 8 **10**
Plot Block Treatment	13 1 **7**	32 2 **13**	51 3 **17**	70 4 **1**	89 5 **14**	108 6 **13**	127 7 **11**	146 8 **12**
Plot Block Treatment	14 1 **18**	33 2 **7**	52 3 **5**	71 4 **3**	90 5 **8**	109 6 **4**	128 7 **9**	147 8 **7**
Plot Block Treatment	15 1 **16**	34 2 **11**	53 3 **13**	72 4 **4**	91 5 **3**	110 6 **2**	129 7 **18**	148 8 **11**
Plot Block Treatment	16 1 **6**	35 2 **16**	54 3 **10**	73 4 **2**	92 5 **10**	111 6 **1**	130 7 **13**	149 8 **3**
Plot Block Treatment	17 1 **11**	36 2 **15**	55 3 **11**	74 4 **8**	93 5 **18**	112 6 **9**	131 7 **5**	150 8 **14**
Plot Block Treatment	18 1 **3**	37 2 **6**	56 3 **8**	75 4 **11**	94 5 **15**	113 6 **5**	132 7 **17**	151 8 **15**
Plot Block Treatment	19 1 **9**	38 2 **1**	57 3 **2**	76 4 **18**	95 5 **12**	114 6 **15**	133 7 **7**	152 8 **18**

Treatment no.	Blend components
1	Peat control
2	M1 100%
3	M2 33% / M1 66%
4	M3 33% / M1 66%
5	M2 100%
6	M2 66% / M1 33%
7	M3 33% / M2 66%
8	M3 100%
9	M3 66% / M1 33%
10	M3 66% / M2 33%
11	M4 33% / M1 66%
12	M4 100%
13	M4 66% / M1 33%
14	M2 33% / M4 66%
15	M3 33% / M4 66%
16	M2 66% / M4 33%
17	M3 66% / M4 33%
18	M3 33% / M4 33% / M1 33%
19	M3 33% / M2 33% / M4 33%

Figure 10b. Trial plan for rosemary set out on an ebb and flood bench split into four sections separated by Perspex sheeting.

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.

Name	Dr Barry Mulholland
Position	Project Lead and Director of Horticulture
Organisation	RSK ADAS Ltd
Signature	
Date	13/03/2019

Statistical analyses authorised by:

Name	Andrew Watson
Position	Institute Statistician
Organisation	Quadram Institute Bioscience
Signature	ANDREW WATSON.
Date	13/03/2019

Report authorised by:

Name	Dr Barry Mulholland
Position	Director of Horticulture
Organisation	RSK ADAS Ltd.
Signature	
Date	13/03/2019

Name	Click here to enter text.
Position	Click here to enter text.
Organisation	Click here to enter text.
Signature	Click here to enter text.
Date	Click here to enter a date.