



Horticultural Fellowship Awards

Interim Report Form

Project title: Sustainable resource use in horticulture: a systems approach to delivering high quality plants grown in sustainable substrates, with efficient water use and novel nutrient sources.

Project number: CP 095

Project leader: Dr Paul Alexander, The Royal Horticultural Society (RHS).

Report: Annual Interim Report, June 2013

Previous report: N/A

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Location of project: RHS Garden Wisley

Industry Representative:

Neil Bragg

Date project commenced:

13th November 2013

Date project completed
(or expected completion date):

13th November 2017

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AUTHENTICATION

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.

Paul Alexander
Project Leader
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1. Progress Against Objectives

Objectives

Objective	Original Completion date	Actual Completion Date	Revised Completion Date
1. Familiarisation with the Horticultural sector	December 2013		
2. Support RHS Wisley for on-going experimentation & advisory duties	July 2013		
3. Propose, develop & initiate new, small-scale experiments on growing media and water-use efficiency.	December 2013		
4. Begin Literature Review of Novel Nutrient Sources	July 2013		
5. Present progress at a range of committees/meetings	July 2013		November 2013
6. Attendance at relevant technical meetings/scientific conferences	July 2013		November 2013
7. Undertake FACTS (hort) Qualification	December 2013	April 2013	
8. Chair Workshop to introduce University of Reading (UoR), East Malling Research (EMR) and RHS staff to the interests & capabilities of each other.	July 2013		December 2013

Summary of Progress

The project was due to start on 1st July 2012, however the horticultural scientist (Gracie Barrett) did not commence employment until the 13th November 2012. The first annual report is therefore based on 6 months, rather than 1 year's work. Below is a summary of progress to date:

1. *Familiarisation with the Horticultural sector:* A number of nurseries and growing media manufacturers have been visited. A good understanding of commercial production systems is developing which is feeding into research ideas. A more detailed summary of visits is included in section 2.
2. *Support RHS Wisley for on-going experimentation & advisory duties:* Experimental work at RHS Wisley is highly seasonal, and opportunities to support others have been limited to date. The Horticultural Scientist attended RHS Chelsea flower show in May, working on the RHS information stand giving customer advice.
3. *Propose, develop & initiate new, small-scale experiments on growing media and water-use efficiency:* An experiment investigating the interaction between amateur growing media and fertilisers was set-up in the RHS Field Research Facility in February. Data collection is underway (see section 4) and the experiment will be completed by the end of July 2013.
4. *Begin Literature Review of Novel Nutrient Sources:* A general review of literature covering the three major topics of the fellowship (Sustainable growing media, water-use efficiency & novel nutrient sources) has been under-taken. A summary of the findings to date and proposed topics for specific reports/publications is presented in section 3.
5. *Present progress at a range of committees/meetings:* Given the early phase of the project, presentation of research outcomes has not yet been possible. However, the project has been introduced at a number of meetings to date (see appendix 1). It is hoped that this will provide future platforms for dissemination of the findings.
6. *Attendance at relevant technical meetings/scientific conferences:* The horticultural Scientist attended the ISHS International Symposium on 'Growing media and soil less cultivation' which took place in The Netherlands (June 2013). Further attendance at a number of conferences and meetings is planned for the coming months (see appendix 2).

7. *Undertake FACTS (hort) Qualification:* This objective has been completed; the qualification was obtained in April 2013.
8. *Chair Workshop to introduce University of Reading (UoR), East Malling Research (EMR) and RHS staff to the interests & capabilities of each other:* Meetings have taken place with staff at UoR, The Warwick crop centre and EMR, to investigate research already being under taken in areas relevant to this project. Topics for a future workshop are being considered, it is recommended that this is planned for the autumn/winter 2013 when the project is further advanced.

Training undertaken

FACTS (Fertiliser Hortic) training was undertaken by the trainee horticultural scientist and resulted in FACTS qualification.

Expertise gained by trainees

The FACTS training provided a useful insight into nutrient management in a wide range of commercial horticultural production systems. This will enable the trainee horticultural scientist to support the RHS advisory team in matters relating to plant nutrition.

Other achievements in the last year not originally in the objectives

A workshop for PhD supervisors was attended in November and provided an opportunity to discuss the best ways to provide supervision for PhD students. The current supervisory structure at the RHS was outlined, and potential problems arising were considered. This will aid the horticultural scientist later on in the course of the fellowship project, when PhD student supervision may be undertaken.

The horticultural scientist also participated in the RHS annual PhD symposium, in which PhD students currently affiliated with the RHS presented their work. This enabled the horticultural scientist to learn about the spectrum of work going on in RHS science and network with a range of academic staff and students.

Changes to Project

Are the current objectives still appropriate for the Fellowship?

No Changes to be made at this point

2. Career Development & Networking

Background

This section demonstrates that the trainee's knowledge and understanding of horticulture is developing. In line with the objectives set for year 1, the current approaches to sustainable practice in both the commercial & amateur horticultural sectors are being investigated. This covers:

- Sustainable growing media (peat-reduced and/or peat-free)
- Nutrient Management practices and nutrient-use efficiency
- Irrigation systems and water-use efficiency

This is being achieved through:

Nursery Visits

These cover a range of commercial nurseries from small family run businesses, to large producers who supply supermarkets and DIY retailers (full list in Appendix 1). The aim was to gain an insight into all major plant production systems in the UK. To date visits have included hardy nursery stock, protected ornamentals and edibles (salads & herbs). These visits are being used to acquire knowledge about sustainable growing practices in place, to identify areas where growers feel they lack the information required to change or modify their existing practices and to identify other perceived barriers to the adoption of more sustainable systems.

Growing Media Manufacturers

Visits have taken place to a number of manufacturers producing peat-free and peat-reduced products based on materials such as bark, wood fibre and green compost (full list in Appendix 1). Trips around factories and laboratories have allowed investigation of the manufacture processes and identification of key qualities for effective growing media. This has enabled the horticultural scientist to develop a greater understanding of the complexity and intricacies of growing media manufacture.

Research Institutes and Universities

Meetings with researchers from EMR, UoR, Warwick Crop Centre and Harper Adams College have taken place to identify areas in which research is already underway and to explore the possibility of collaborative projects. Less formal conversations have also taken place with other academics at meetings and conferences (full list in Appendix 1).

Summary of Findings

Commercial Horticulture

Most of the UK nurseries visited to date are experimenting with peat-reduced or peat-free growing media. This has come about for a number of reasons; primarily there has been pressure by the UK government and other non-governmental organisations to remove peat from growing media for environmental reasons. Amateur and professional growers are also becoming increasingly aware of the need to produce plants more sustainably. This in conjunction with the rising cost and more limited availability of good quality peat in the last 2 years has meant peat-free and peat-reduced growing media are becoming more desirable. As a result of this move away from peat, many media manufacturers are investing considerable time and resources in the development of their professional peat free/peat reduced media. Extensive testing, trialling and careful quality control have allowed them to produce a consistent and reliable product. This has helped to erode the negative connotations some professional growers have of peat-free/peat-reduced media. Indeed, several producers of bedding plants and hardy ornamentals visited believe that the peat-free media they are now using is superior to their previous peat based mix.

Some sectors of the industry have clearly made more progress than others in becoming less reliant on peat. Certain plant production systems lend themselves more readily to peat-reduced/peat-free media than others e.g. protected and hardy ornamental container plants. In contrast, lettuce nurseries which supply salad growers with young lettuce plugs rely on mechanised, high throughput systems designed specifically for peat media. In these systems peat-free media perform poorly because they have different physical properties. In such systems a peat substitute would need to be tailor made for application at each stage in the existing set-up. There is certainly scope for research examining suitable materials to replace peat in these growing systems. In general, there appears to be a good range of professional peat-reduced and peat-free products on the market which are fit for purpose, and certainly meet the requirements of most ornamental growers.

However, the performance of these products depends very much on the management practices of the nurseries:

Nurseries with varied plant production systems

On nurseries which propagate new plant material, media based on different raw materials have to be used for different stages of plant development. Coir containing media are generally much better suited to seed and cutting propagation than wood based materials. As plants mature and reach liner stage, wood containing media become suitable. Where one material has been used in the past (peat), several may need to be used in peat-free production. This may present a barrier to change for some growers because it involves a period of familiarisation followed by modification of existing practices which can be costly (e.g. altering irrigation, fertiliser, Pest and disease regimes etc.). This familiarisation period can involve extensive trialling of different media mixes and lead to potential plants losses. While several nurseries visited have invested significant time and money going through this process with success, adoption of this approach will depend on the resources available to individual nurseries.

Water management and Irrigation Systems

The type of Irrigation system selected for use on a nursery will depend primarily on the plant type in production as well as the cost to install and run it. The growing media in use can also have an important impact on irrigation efficiency. For growers utilising products containing wood fibre and bark it is often noted that containerised plants do better when irrigated more frequently, but with a reduced volume of water.

In one large commercial nursery, peat-reduced and peat-free growing media were being trialled with ebb and flow irrigation. In this system, water and nutrients are absorbed from the bottom of the containers, rather than being applied to the top surface with sprinklers or drippers. The physical characteristics of peat mean that water applied to the bottom of the pot will become evenly distributed through-out. Conversely, in a bark or green compost based media, distribution of water and nutrients via this method was clearly much less even. Root growth became confined to a much smaller area (the wet areas) and plant quality was reduced relative to plants grown in peat mixes.

In nurseries where plants were irrigated with over-head sprinklers the bark and green compost products often performed as well as, or better than the peat based mixes. In fact, because these media tend to dry out from the top downwards they tend to discourage the growth of liverwort and mosses. This represents a significant advantage to growers because the labour costs related to cleaning up marketable plants are significantly reduced.

Nutrient management & fertilisation systems

The performance of different growing media is also related to the way in which plant nutrients are applied. Controlled/slow release fertilisers, inorganic base fertilisers and inorganic liquids feeds are all likely to vary in efficiency when added to different growing media. While some of these differences are addressed by the media manufacturers who aim to incorporate fertiliser into their mixes, nutrient efficiency will also vary according to the irrigation systems in place and whether production systems are protected.

Conclusions

There is clearly a need to investigate which combinations of media/irrigation system/nutrient supply work best. The main issue for growers seems to be that there are no general guidelines for growing nursery stock in different peat-free media. Any change in management practice albeit switching to a peat-free media or incorporating a new type of fertiliser needs to fulfil the following criteria:

1. MAINTAIN OR INCREASE plant quality/marketability/shelf-life
2. MAINTAIN OR REDUCE costs (fertiliser inputs, labour, production time-scales)
3. INCREASE sustainability (reducing fertiliser inputs & leaching, reducing water inputs)

These criteria can be used to develop research which evaluates the suitability of growing media mixes based on a range of raw materials, under different irrigation systems and with different nutrient management strategies.

Gardeners/Amateur Growers

Several manufacturers of professional peat-free media also make amateur products. Results obtained from these products very much depend on how they are managed (frequency of watering, type of nutrition applied, volume of water applied etc.). Again, there are no general guidelines to help gardeners get the best from these products; packaging and company website advice are often very limited.

Time has been spent with RHS specialists in propagation and irrigation to better understand some of the specific challenges facing the amateur grower. The RHS uses 90% peat-free growing media in plant production, and has been gradually phasing out peat use over several years.

A range of different media and management practices have been assessed, supplying a wealth of knowledge which is being drawn upon to develop best practice moving forwards.

The main problem for amateurs using peat-free media is product quality control, as bag to bag consistency remains poor. Unlike the professional sector, there seems to be little incentive for media manufacturers to produce good quality, reliable products. Price, rather than performance seem to be the main driver in the design of their mixes. For amateur gardeners, this makes the production of good quality peat-free plants very challenging.

The effective management of amateur peat-free media is being explored in the first experimental work of the fellowship; this work is outlined in section 4.

Future development

There are several sectors of commercial horticulture that remain to be investigated including soft fruit production (strawberries, particularly where coir grow bags are being used) and container tree production. Tree production may be of particular interest because plants can remain containerised for many years. Long-term stability of growing media and organic/slow release nutrient sources may be useful areas for future research within this sector.

The following actions will be on-going:

- Attendance at grower meetings to keep informed about current issues.
- Visits to new and previously visited nurseries to increase knowledge base and maintain contacts.
- Observation and participation in grower trials where suitable, and to explore the potential for collaborative projects with some growers.

3. Literature Review

Background

This section outlines progress made in the assessment of existing scientific literature, relating to the three major themes of the fellowship outlined in section 2:

1. Sustainable growing media (peat-reduced and/or peat-free)
2. Nutrient Management practices and nutrient use efficiency
3. Irrigation systems and water use efficiency

Summary of Findings

Sustainable Growing media (peat-reduced and/or peat-free)

A large number of authors have investigated the use of different organic and mineral materials in container growing media. Many (but not all) tend to be waste materials from industrial, agricultural and domestic streams. Comparing these studies is problematic because they don't adopt consistent methodology (e.g. duration of the experiment, the plant choice, the media mixes, the control mix etc.) or measure the same chemical and physical properties of the materials involved. What's more materials tend to be trialled over one production season, when in reality media may be in use for much longer periods. This is particularly problematic for organic materials, where physical structure is likely to change significantly over these longer time scales.

The approach to assessing the suitability of potential growing media materials needs to be more prescriptive, something this fellowship hopes to achieve. Standard measurements of the physical and chemical properties of growing media mixes need to be established (air filled porosity, available water, container capacity etc.), so that results for different materials can be more easily compared. Experimental work needs to take place over realistic time-frames and media properties need to be monitored alongside measures of plant growth and quality.

Evidence in the literature indicates that many different materials can produce good quality plant growth given the correct management. However, the practicality of many of these materials is questionable. To be a practical feedstock for growing media the materials need to meet (or go some way to meeting) the following criteria:

- **Supply:** Readily available, stable & consistent supply
- **Economics:** Competitive price (including transport costs if non-local source)
- **Practicalities:** Work within existing production systems (weight, application in mechanised systems, appearance, smell, consumer perception etc.)

Proposed Literature Review for publication

An overview of different growing media materials will be carried out, comparing different materials with regard to their chemical and physical properties and within the context they have been used (time-scale of the study, plant type, irrigation used etc.). It would also be useful to scrutinise these materials according to the above criteria and identify the organic and inorganic materials that may warrant further investigation within the fellowship.

Nutrient Management practices and nutrient-use efficiency

In the next few years there is likely to be pressure on commercial growers to increase the efficiency of their fertiliser usage. Fertilisers are increasingly expensive, and the raw materials used to make them are in some cases a finite and dwindling resource (e.g. rock phosphate). UK legislation relating to water quality (Water Framework directive, nitrate vulnerable zones and proposed phosphate vulnerable zones) is also likely impact on the commercial horticultural sector driving nurseries to use fertilisers in a more sustainable way.

There are two possible avenues of research which might help them achieve this:

1. **Novel Nutrient sources:** The availability of new, sustainable sources of nutrients like phosphate.
2. **Improving Nutrient-use Efficiency:** Developing practices which increase plant nutrient use-efficiency and reduce leaching.

1. Novel Nutrient Sources

A large number of studies evaluate industrial and agricultural by-products/waste materials as sustainable nutrient amendments in growing media. These include poultry manure, biosolids (derived from the treatment of sewage), wool waste, paper sludge and anaerobic digestates (AD). Studies investigating rock dusts/powders and other mineral nutrient sources in container systems may also warrant further scrutiny. These novel materials have been incorporated into growing media in numerous proportions and forms and there is a great deal of conflicting evidence with regard to their effectiveness. The results depend on:

- The materials making up the media to which they are added
- How they are processed prior to addition (processes like composting can create more favourable characteristics by reducing pH or salt content).
- The production systems to which they are added (type of irrigation, plant type, residence time in the container etc.).

2. Improving Nutrient-use Efficiencies.

Nutrient uptake efficiencies in commercial production systems are typically low; studies that have examined them have found on average that less than 50% of applied nitrogen (N) and phosphate (P) is recovered by plants. Nutrient uptake efficiency is greatly influenced by:

1. The form in which nutrients are supplied (Liquid feeds, CRFs, base inorganic fertilisers etc.).
2. How nutrients are applied (fertigation, controlled release plugs etc.)
3. The physicochemical characteristics of the growing media to which they are applied
4. The timing of nutrient application (Time of year, time of day etc.)

There appears to be a general lack research investigating these factors on a very basic level. For instance, how do different growing media materials influence plant nutrient efficiency? Do particular forms of nutrients perform better with particular materials? How does the type of irrigation system in place impact on this? Current practice understandably appears to focus on minimising risk in terms of plant production. Fertilisers are added at a concentration to match perceived plant need but little work has examined whether this system can be further refined.

There is some evidence that particular amendments such as clays or biochar might improve nutrient management in growing media, making some nutrients more available and also potentially reducing leaching by modifying physiochemical properties (e.g. cation exchange capacity). Could these be used in container plant systems to regulate the availability of particular nutrients?

Proposed Literature review and Publication

There is scope to produce two distinct literature reviews dealing with different aspects of nutrition in horticultural growing systems.

1. Novel, sustainable nutrient sources

It would be useful to review some of the less obscure novel nutrients that have been investigated to date. This will include summarising the systems in which they have been trialled and how they fit the three criteria of supply, economics and practicality previously outlined in this section (p11). This will identify novel nutrient sources worthy of further investigation.

2. Improving Nutrient-use Efficiencies

It would be timely to review studies which have investigated the impacts of growing media amendments on nutrient uptake efficiency. This could include biochar, clay minerals and synthetic materials which may help to moderate the supply of nutrients to plants and reduce leaching. Again this will identify materials which may be of particular interest.

Irrigation systems and water-use efficiency

Studies investigating irrigation systems and water-use efficiency in horticultural production are numerous and comprehensive. The main focus appears to be on reducing water inputs, while maintaining plant quality and harvest yields (e.g. regulated deficit irrigation and partial root zone drying). There is less available information on the impacts of different growing media on plant water-use efficiency. From work already carried out in this project, it is clear that different materials retain and release water in different ways. This raises the fundamental question: Do some growing media require less water than others to produce the same plant quality?

As highlighted in the section 2, there are no clear guidelines for growers with regards to the type, frequency and duration of irrigation suited to different growing media to give optimum results. There are therefore several areas which require reviewing:

- The impact of different growing media on plant water-use efficiency.
- How different irrigation techniques interact with growing media to impact on plant water-use efficiency.
- If particular materials can be added to media mixes to enhance plant water-use efficiency (for instance, biochar).

4. Science Section

Abstract

As the fellowship has only been under-way for 7 months, there are no complete experiments to report on. An abstract of the first experiment is given below, a full report will be provided in the next Interim report due in June 2014.

Experiment 1: The impact of different growing media and fertiliser combinations on the quality of container grown *Pelargonium* 'Maverick Red'.

In the last 20 years there has been an increasing drive by the UK government to move horticulture away from peat containing growing media. This has presented a challenge for amateur and professional growers alike, as they strive to produce quality plant growth in peat-free materials. For amateur gardeners in particular, the availability of peat-free growing media is limited and there are few guidelines for water and nutrient management in these materials. This is problematic because different peat-free growing media are based on various materials including coir, wood fibre or green waste compost. The physical and chemical properties of these materials vary widely, thus each growing media product is likely to behave differently under the same watering and feeding regime.

Whilst the RHS has undertaken research into the management of water management on plant quality in a variety of growing media mixes (peat and peat-free), there has been a limited focus on plant nutrition. There are many questions which need to be addressed so that amateur gardeners can be provided with basic information on fertiliser usage in peat-free media, these include; does the fertiliser product affect the resultant plant quality when using different growing media? Is there a need to vary the rate or type of feed in use depending on the material on which the growing media is based?

To start to address some of these questions, we have tested two brands of liquid fertilisers (an inorganic product and a product based on organic nutrient sources) in four different growing media products (based on coir, wood fibre, peat & green compost) with the following aims:

1. To determine how off-the shelf amateur media impact on plant quality when used alone or in combination with two different liquid feeds
2. To investigate the factors driving differences in plant quality between different media/feed combinations (Nutrient availability, media moisture retention ability etc.

5. Future Work

The broad aim for the next 12 months will be to improve the existing knowledge of the interactions between standard growing media materials when mixed. This will include identifying the best way to manage water (and eventually nutrients) in these mixes. The objectives for year 2 are outlined in the table below; the proposed programme of research is described with reference to these objectives.

Year 2 Objectives	Original Completion date
1. Develop & Initiate experiment focusing on efficient water delivery/use (possibly at EMR).	September 2014
2. Deliver Literature review of existing knowledge of nutrient Sources. Publish if suitable.	December 2014
3. Proposals for Experimentation in Year 3 to explore nutrient provision, initially focusing on one 'simple' substrate but expanding into mixes.	December 2014
4. Development of methodologies to deliver experimental aims (use lab at Reading).	December 2014
5. Presenting information and research findings at grower/technical meetings.	July 2014
6. Present research findings to RHS Science committee, HDC Studentship meeting & appropriate staff seminars at RHS, UoR & EMR.	July 2014
7. Exposure to RHS Shows, advisory support at Wisley & RHS press office.	September 2014
8. Chair workshop for relevant UoR, EMR & RHS staff to identify research themes for collaborative opportunities.	July 2014

Proposed Programme of Research

1. *Agree a standard growing media mix or mixes which can be used throughout the fellowship, to provide a benchmark for plant performance (objective 4).*

If the performance of a growing media mix is to be compared over several different experiments it is important that a standard or control treatment is established. This will highlight any differences in plant growth that might occur because of something other than the media mix (e.g. differences in location or climate of successive experiments). Several standard mixes may need to be developed depending on the context in which they are used (with fertiliser, without fertiliser etc.).

2. *Characterise the physical and chemical properties of standard growing media materials and mixes of these materials (Objective 4)*

Standard protocols for defining these properties will need to be developed. These methods need to be high-throughput and economical, so that they can be used repeatedly over the course of the fellowship. At this point in the project a clear understanding of these materials in isolation and how they behave in mixes needs to be developed.

3. *Identify mixes that work particularly well and evaluate according to supply, economic and practicality criteria (Objective 4/5)*

Current work with propriety amateur growing media mixes indicates their use will be limited going forwards. The content of these mixes is poorly defined and highly variable meaning it is not possible to identify characteristics which make them effective/ineffective. In order to be able to draw meaningful conclusions about the impacts of different media mixes on plant growth, we need to produce bespoke, controlled mixes from raw materials. Mixes based on different proportions of raw materials (coir, bark, wood fibre etc.) will be investigated using standard fertilisation and irrigation techniques. The impacts of these mixes on plant quality will be recorded.

At this stage a cost/benefit analysis of proposed mixes should be carried out, to ensure their use on nurseries or in gardens is feasible. The criteria outlined in section 3 can be used to this end. Results should be presented at grower/technical meetings for feedback. Industry contacts made in year 1 can also be consulted (objective 5).

3. Investigate the performance of these mixes with different irrigation systems, representative of those in professional use (Objective 1)

As highlighted in section 2, the performance of growing media depends on the growing system in which it is used. There appears to be an important interaction with irrigation type which needs to be explored. Some of the key questions are:

- Can a mix of several different materials work as effectively as peat media across a broad spectrum of irrigation systems?
- Can some mixes of materials maintain plant quality while requiring less water?
- Do certain materials lend themselves particularly well to certain irrigation systems?

Methods to investigate how root architecture is related to water and nutrient distribution in containers may also be developed as part of this research objective.

5. Compare plant nutrient-use efficiency between media mixes when using different sources of conventional fertilisers (Objective 3)

Very little is currently known about how peat-free growing media interact with conventional fertilisers (e.g. liquid feeds, base fertilisers, CRFs).

- Do certain mixes produce better nutrient-use efficiencies?
- Which combinations of materials retain nutrients better and reduce leaching?
- How is this related to plant quality?

Addressing some of these questions in years 1/2 will help inform experiments in years 3/4. These will focus on novel nutrients and the interaction between growing media, fertilisers and irrigation. Identified below are some key milestones for the 12 months:

Key Milestones for the next 12 months

Milestone	Proposed Completion Date
Complete first experiment investigating the impact of different growing media & fertiliser combinations on plant growth. This includes analysis and dissemination of the results. <i>(Relates to Objective 3, year 1)</i>	November 2013
Choose topic for research workshop, propose date, identify attendees, organise venue and issue invites <i>(Relates to Objective 8, year 1)</i>	November 2013
Complete literature review on growing media materials and have review of novel nutrients sources underway. <i>(Relates to Objective 4, year 1 and Objective 2, year 2)</i>	June 2014

Knowledge and Technology Transfer

N/A at this stage

Glossary

AD: Anaerobic digestate

UoR: University of Reading

EMR: East Malling Research

References

N/A

Appendices

Appendix 1: Meetings & visits to date

The table below lists the meetings attended and visit made during the last 6 months.

Date	Visit/Meeting	Outcomes
14/11/12	PhD Supervisors Meeting	<ul style="list-style-type: none"> • Provision of effective PhD Supervision with academics from several universities • Introduced the fellowship project
15/11/12	Growth Media Association Meeting	<ul style="list-style-type: none"> • Current issues for growing media manufacturers • Peat reduction/peat free debate • Introduced the fellowship project
21/11/12	RHS PhD Symposium	<ul style="list-style-type: none"> • Current Research projects on going & other partners affiliated with RHS
22/11/12	RHS Science Committee Meeting	<ul style="list-style-type: none"> • Introduced fellowship project to the Science Committee
28/11/12	DEFRA Sustainable Growing Media Task Force Meeting	<ul style="list-style-type: none"> • Current issues for growing media manufacturers/peat-free debate
06/12/13	The UoR (Steve Robinson)	<ul style="list-style-type: none"> • Discussed the University of Readings role in the fellowship • Discussed Novel Nutrient sources & research ideas
07/12/13	Melcourts growing media (Neil grey)	<ul style="list-style-type: none"> • Production & distribution of Melcourt's bark based growing media
10/12/12	EMR (Mark Else)	<ul style="list-style-type: none"> • Investigated the scope of similar projects at EMR & discussed potential collaborations
11/12/12	Lowaters Nursery (Ian Ashton)	<ul style="list-style-type: none"> • Medium-scale protected ornamental production, from propagation to saleable plants
17/12/12	Vital Earth (Arnie Rainbow)	<ul style="list-style-type: none"> • Production & distribution of green waste compost based growing media
17/12/12	Boultons Nurseries (Lee Melady)	<ul style="list-style-type: none"> • Small-scale hardy ornamental production in media containing green waste compost
19/12/12	Harper Adams University (Jim Waterson & Neil Bragg)	<ul style="list-style-type: none"> • Plant trials with biochar • Discussed biochar potential in growing media

29/01/13	Lowers Nursery (Charles Carr)	<ul style="list-style-type: none"> • Technical aspects of protected ornamental production
29/01/13	VHB herbs, West End Nursery. (Ivan Smith)	<ul style="list-style-type: none"> • Large-scale potted herb production • Viewed peat-reduced & Peat-free growing media trials
05/02/13	Pren Plants (Will George)	<ul style="list-style-type: none"> • Small-scale hardy ornamental production
05/02/13	Newplace Nurseries (John Hedger/Mike Norris)	<ul style="list-style-type: none"> • Large-scale hardy ornamental liner production • Ornamental tree production (container & field)
06/02/13	John Hall	<ul style="list-style-type: none"> • A day spent with Jon to meet a number of his clients on their nurseries. • Discussed sustainable horticultural practices
06/02/13	Binsted Nurseries & Farplants Distribution (Martin Emmett)	<ul style="list-style-type: none"> • Large-scale protected ornamental production from propagation to saleable plants • Large scale plant distribution site
06/02/13	VHB Herbs, Runcton Nursery (Chris Moncrieff)	<ul style="list-style-type: none"> • Large-scale pot & Cut herb production
06/02/13	Roundstone Nurseries (Gavin Miskelly)	<ul style="list-style-type: none"> • Large-scale pack bedding & nursery plant production (bedding, protected ornamentals & herbs)
06/02/13	Tangmere Airfield Nurseries (Bob Thorn)	<ul style="list-style-type: none"> • Large-scale pepper production
20/02/13	Bord na Móna (Dearbhail Nichaualain)	<ul style="list-style-type: none"> • Media design, production & quality control (peat & green waste compost)
21/02/12	Bord na Móna (Anna Kavanagh)	<ul style="list-style-type: none"> • Peat for energy production, biomass burning & the conflicts with growing media production • Peat land restoration
06/03/13	Melcourt Open Day (Catherine Dawson, Neil Grey)	<ul style="list-style-type: none"> • Peat-free media from a grower's perspective • Included a talk by Neil Alcock of Seiont Nurseries
18 th - 20/03/12	Bulrush Media Factory (Neil Bragg & Anne McCann)	<ul style="list-style-type: none"> • Production, distribution & quality control of peat based media • Wood fibre manufacture for peat-reduced mixes

		<ul style="list-style-type: none"> • Peat bog restoration: the challenges, timescales etc.
09/04/13	Biochar Meeting at Harper Adams University	<ul style="list-style-type: none"> • Meeting with a number of parties interested in the potential of biochar in growing media • Presented the fellowship project • Viewed trials with various nutrient sources & biochar in containerised trees
22/04/13	Steve Carter: Technical Manager of Fleurie Nursery	<ul style="list-style-type: none"> • General introduction and discussion about research ideas to date at the RHS
24/04/13	Managing RHS Science projects	<ul style="list-style-type: none"> • Science group meeting at Wisley to discuss techniques for managing science projects within the RHS.
10/05/13	InCrops: Sustainable growing media (Meeting at Rothamsted Research)	<ul style="list-style-type: none"> • Talks and discussion on sustainable growing media by scientists and industry representatives
15/05/13	Fellowship Review Meeting	<ul style="list-style-type: none"> • Progress review meeting with fellowship staff, HDC & Industry representatives • Assessment of progress to date and of on-going research plan
25/05/13	RHS Chelsea Flower Show	<ul style="list-style-type: none"> • Worked on the RHS Environment Stand • Provided visitors with general information on the RHS, gardening etc.
30/05/13	British Soil Science Society: Soil amendments (Meeting at Edinburgh University)	<ul style="list-style-type: none"> • Talks and discussion on soil amendments for use in horticulture (biochar, composts, rock dusts etc.)
05/06/13	Warwick Crop Centre (Rob Lillywhite & Catherine Keeling)	<ul style="list-style-type: none"> • Visited a trial using AD as a liquid fertiliser for commercial strawberry production
13/06/13	Stockbridge Technical College (Julian Davies)	<ul style="list-style-type: none"> • Visited commercial trials of growing media mixes and fertilisers
17 th – 21/06/13	GroSci 2013 'International Symposium on Growing Media and soilless cultivation', Leiden, Holland	<ul style="list-style-type: none"> • Attended a number of talks outlining recent work on growing media. • Visited a number of Dutch nurseries and a Dutch media manufacturer

Appendix 2: Planned Meetings & visits during the next reporting period

The table below lists the confirmed meetings and visits proposed for the next reporting period.

Date	Proposed Visit/Meeting
26/06/13	PlantWorks: Visit to factory to learn more about their products
09/07/13	Stockbridge Technical College: To view trials being carried out for Bulrush
9th- 10/09/2013	Persnore College : HDC Studentship Conference
10/07/13	RHS Hampton Court Flower Show: Work on the RHS advice stand
22/07/13	Visit FP Matthews Nursery: To learn more about container tree production
23/07/13	Meeting with David Hutchinson, horticultural Consultant (DHS Ornamentals)
28/08/13	Visit to Fleurie Nursery to view production systems.

Appendix 3: Images from experiment 1:

The impact of different growing media and fertiliser combinations on the quality of container grown *Pelargonium* 'Maverick Red'

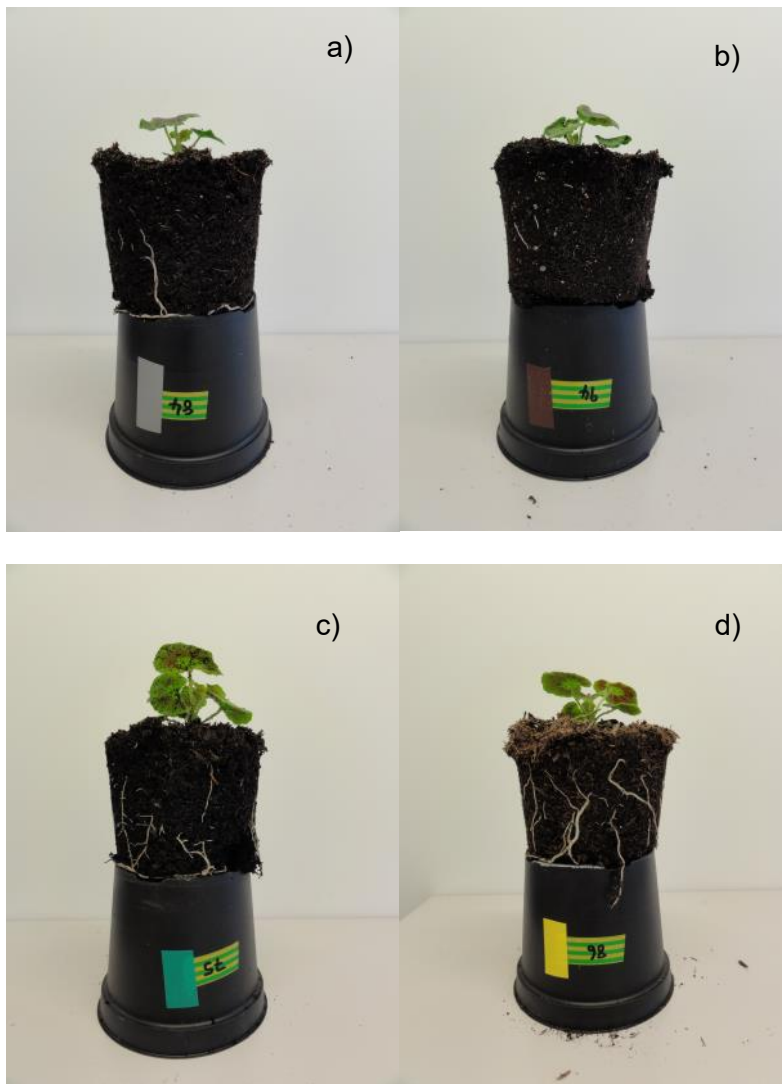


Image 1 The root development of *Pelargonium* 'Maverick Red' in different proprietary growing media: a) peat based b) coir based, c) green compost based, d) wood fibre based. Plants were harvested 5 weeks after plugs were planted (into 1 litre pots) and before the feeding treatments were imposed.



Image 2 The set-up of experiment 1 in the RHS field research facility