

Project title: The Bedding and Pot Plant Centre – new product opportunities for bedding and pot plant growers.

Objective 4. Adopting new responsibly sourced growing media blends

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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.

Thomas James

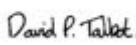
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Grower Summary

Headline

- Marketable pot plants were successfully produced in peat-free growing media within an ebb and flood system
- Commercial quality plug plants were successfully produced in peat free growing media albeit there were differing responses to the various media in the species trialled
- Peat-free growing media blends tested exhibit different water holding properties; water management should be adjusted to produce conditions suitable for the plant species being grown, grouping plants with similar requirements.
- Peat free growing media also tend to exhibit higher conductivities (EC) and these may have to be accounted for in fertigation regimes

Background

The Bedding and Pot Plant Centre (BPPC) has been established to address the needs of the industry via a programme of work to trial and demonstrate new product opportunities and practical solutions to problems encountered on nurseries.

In 2011, Defra introduced a voluntary phase-out target of 2030 for professional growers of fruit, vegetables and ornamental plants. In December 2021, Defra announced plans to ban the use of peat in the amateur sector in England and Wales by the end of this Parliament and has been consulting on the phasing out of peat in the professional sector by 2028. The reduction of peat use in horticulture is expected to be achieved by using a blended range of materials rather than relying solely on one or two main ingredients, not least due to availability of alternative materials.

Where proprietary peat-free growing media blends have been used with some success on nurseries, the need to optimise irrigation, nutrition and mechanisation have been highlighted as areas where further support is required by the industry to get the best out of those blends and increase grower confidence. The trial reported below is one out of a series of demonstration trials carried out at various grower sites over two years.

This is the Bedding and Pot Plant Centre report for:

Objective 4. Adopting new responsibly sourced growing media blends. It reports trials carried out at 1. Hills Plants (Pot Plants) and 2. Earley Ornamentals (Propagation).

Summary

1. Hills Plants (Pot Plants)

Plugs of two pot plant species (*Calathea roseopicta* 'Silvia' and *Ficus benjamina* 'Exotica') were potted on 29 September 2021 (week 39) into three proprietary peat-free substrates provided by different manufacturers, and a peat-based growing media (13 cm pots) and grown on under glass at Hills Plants, Runcton until the final assessment on 19 January 2022 (**Figure 1**). *Calathea* and *Ficus* were selected for this trial because *Calathea* don't like to be too dry on capillary matting, and *Ficus* tends to show nutritional problems easily. Plants were potted by hand and set out on benches irrigated via ebb and flood irrigation. The irrigation and feeding regime followed standard commercial practice, with any effects on plant quality recorded. Nursery standard practices were also used for pest and disease control.



Figure 1. Growing media trial set up, Hills Plants, Chichester, 29 September 2021

The peat-based growing media was generally a fine grade, with some woodfibre pieces 1-2 cm long, and perlite. Treatments A, B and C were a fine grade, with treatment B damper than the others and initially became stuck in the pot filling machine, which was resolved by adjusting the flow rate.

Irrigation was applied to most closely suit the peat-based growing media, which tended to hold most water. However, *Calathea* perform better in drier conditions than provided by the peat-based growing media on this system and so plant quality was adversely affected, and several

plants developed scorch (**Figure 2**). An adjustment to the amount of irrigation applied would have improved plant quality in the peat-based growing media. Similarly, when growing in treatments A and C the substrate provided better drainage, therefore growers would need to irrigate more often. Ficus however grew well in the peat-based growing media.



Figure 2. *Calathea* 'Silvia' produced in the peat-based growing media.

Main outcomes for *Calathea* (figure 3):

- Suffered from lack of drying out resulting in 'scorch' symptoms, shorter plant height and poor root development in the peat-based growing media
- Greatest fresh weight and dry weight and root development in treatment C

Main outcome for Ficus (figure 3):

- Best performance in treatment B
- Shortest plants in treatment A
- No root development differences



Figure 3. Comparative images of *Calathea* 'Silvia' (left) and *Ficus benjamina* 'Exotica' (right). 19 January 2022. Peat-based growing media (blue labels), treatment A (yellow labels), treatment B (purple labels) and treatment C (green labels)

Growing media analysis outcomes:

- Treatment B had high initial EC at 647 $\mu\text{S}/\text{cm}$ (compared with 221-442 $\mu\text{S}/\text{cm}$ for the other treatments)

- High final EC for Ficus in all treatments (576-1102 $\mu\text{S}/\text{cm}$) with treatment C at the highest level, linked to high Cl and K in particular without visible impact on plant quality

The increase in EC across all the growing media may be due to the amount of water and liquid feed applied, with water application managed to allow the peat-based growing media to dry back. Where water application is restricted in this way, salts can build up in the growing media if not taken up or utilised by the plants, as they are not flushed through when irrigation is applied. Materials such as bark can provide a greater buffering effect which can help to protect plants against high salt levels.

Some of the growing media included in this trial appear to have been better suited than others for use within this system, with better growth and development of plants grown in the more open and well drained growing media.

It is also worth noting that the source of materials (e.g. manufacturer) and the way they are produced (e.g. size, how fibrous the final product is) can cause the growing media to behave differently, particularly in terms of water holding capacity and this will affect water management requirements.

2. Earley Ornamentals (Propagation)

A propagation trial was set up at Earley Ornamentals, Thirsk on 05 January 2022 (week 1). Seeds of seven plant species (*Antirrhinum* 'Sonnet', Geranium 'Horizon', African Marigold 'Antigua', *Mimulus* 'Mystic', Pansy 'Premier', *Petunia grandiflora* 'Espresso Grande', and *Cosmos* 'Sonata White'), and cuttings of *Sennetti* 'Deep Blue' were sown / stuck into two peat free substrates and a peat-based growing media provided by different manufacturers and grown on under glass until the final assessment on 15 February 2022. Tray sizes were 480 plugs (*Antirrhinum*, African Marigold, *Mimulus*, Pansy, *Petunia* and *Cosmos*), 360 plugs (Geranium) and 84 plugs (*Senetti*). Seeds were machine-sown, and cuttings were stuck by hand. Benches were open mesh and the irrigation and feeding regime followed Earley Ornamentals' standard practice, with irrigation applied via boom and lance and no adjustment to nutrition. Notable outcomes were:

Outcomes for plant quality:

- All plants assessed were marketable, achieving scores of 3 to 5.
- A score of 5 (excellent quality, no damage visible) was recorded for all species in the peat-based media, for the *Senetti*, *Mimulus*, *Cosmos* and Geranium in Treatment B, and for the *Senetti*, *Petunia*, Geranium, and the African Marigold in Treatment C.
- All species scored 4 and above when grown in Treatment B.

- The lowest scores were achieved by the *Mimulus*, Pansy and *Antirrhinum* grown in Treatment C, scoring 3.

The grower had 'gapped' the plug trays where seedlings were undersize or had not survived, and this showed differences between species in the number of plants that germinated and established. The *Mimulus*, *Petunia* and *Antirrhinum* established well with minimal losses. The *Cosmos* and The African marigold appeared most sensitive to the treatments, with most losses in Treatment C and fewest in the peat-based growing media (**Figure 4**). *Cosmos* similarly had most losses in Treatments B and C.

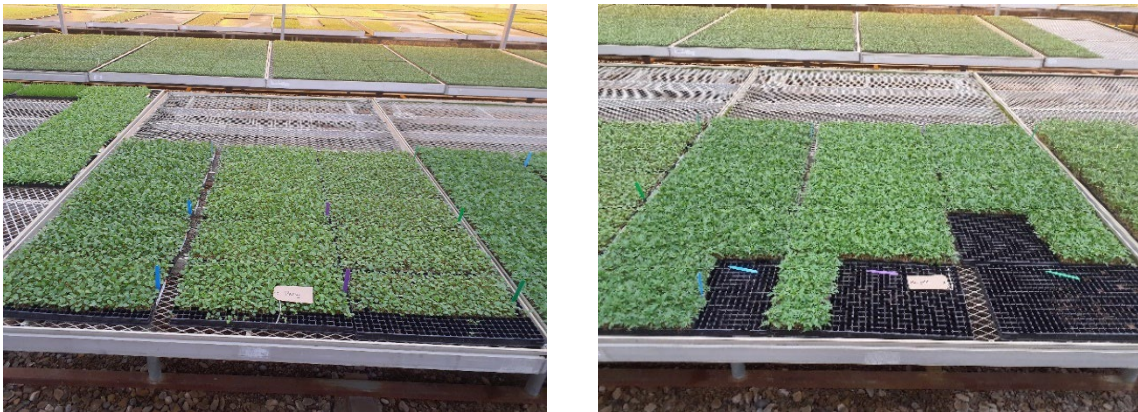


Figure 4. Earley Ornamentals. Growing media trial: Pansy (left) and African marigold (right) after gapping up, 05 January 2022. Peat-based growing media (blue labels), treatment B (purple labels) and treatment C (green labels),

Main outcomes for root quality and plug integrity (**Figure 5**):

- Root quality was consistently good across all growing media treatments for all species, except for *Antirrhinum* in treatment B (score 3) and the *Antirrhinum* and *Petunia* in Treatment C (score 3), where the roots were less well developed.
- Plugs held together well when grown in the peat-based growing media.
- Plugs generally held together well in Treatment B, although there was a tendency for the plug to crumble for *Petunia* and *Antirrhinum*.
- There was a more pronounced tendency for the plugs to crumble in Treatment C (*Mimulus*, *Petunia*, and *Geranium*), but this was linked to plug integrity rather than root quality as these species all scored 3 or 4 for root quality.
- The high EC in Treatment C may have contributed to the poorer root quality scores for *Petunia* and *Antirrhinum*. A substrate EC below 200 $\mu\text{S}/\text{cm}$ is usually recommended for seedlings, above this root damage can be caused, depending on species sensitivity.

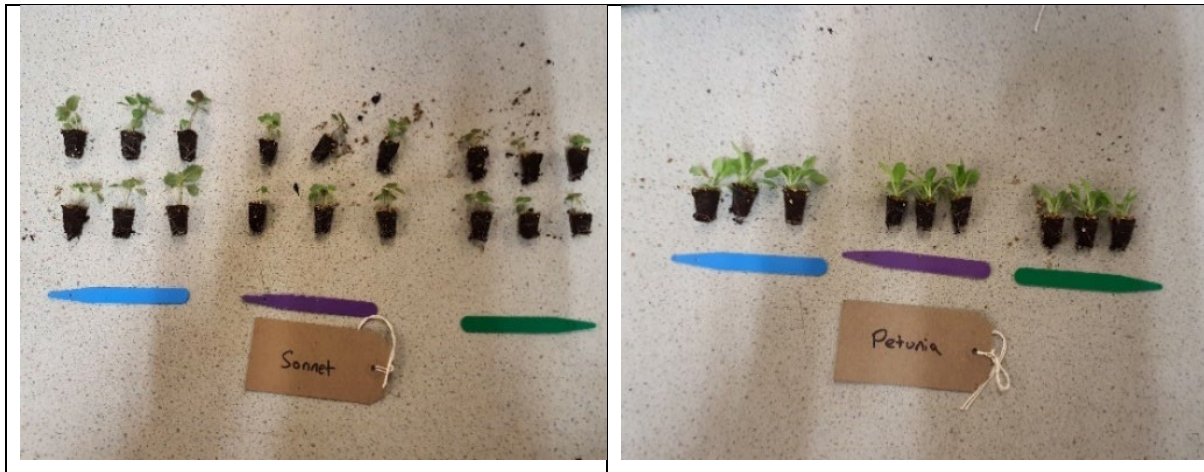


Figure 5. Earley Ornamentals. Root quality: *Antirrhinum* 'Sonnet' (left) and *Petunia grandiflora* 'Espresso Grande' (right). Peat-based growing media (blue labels), treatment B (purple labels) and treatment C (green labels), 15 February 2022

Financial benefits

- A comparison of a sample of growing media products (Fargro, <https://fargro.co.uk/>) indicates that 100% peat growing media (11p/L) is usually offered at a lower price than peat-reduced (9-18% difference) and peat-free (18-73% difference). Peat has historically been the lowest cost substrate, but the price has increased in recent years because of availability and sourcing issues, and this is narrowing the price gap between peat and peat-free media.
- There are other cost implications in transitioning away from peat use. These costs include in-house trials of new substrate and blends (including nutrition / irrigation management), and new machinery (e.g. pot fillers, coir shredders) may be required.

Action points

- Trial new peat-free or peat-reduced growing media before widescale use to fully understand the best water management techniques for each substrate and performance at transplant (plug integrity).
- Select peat-free or peat-reduced growing media to suit the nursery production system, for example ebb and flood, overhead, or hand irrigation, and adjust the irrigation regime to suit the crop being produced.
- Undertake nutrient analysis of substrates before use and adjust the nutrient regime to take account of nutrient levels; irrigation water analysis should also be undertaken with nutrients accounted for within the nutrition programme.
- Encourage strong root development through careful attention to watering (not too wet) and consider allowing slightly longer for roots to develop before transplant.

- The tray/pot/pack filling machine may require adjustment depending on growing media moisture level. The moisture level of the substrate can affect the speed of container filling, with a slower flow rate for moister materials, which can result in under-filled containers.

Science Section

Introduction

The Bedding and Pot Plant Centre (BPPC) has been established to address the needs of the industry via a programme of work to trial and demonstrate new product opportunities and practical solutions to problems encountered on nurseries. Knowledge transfer events including trial open days and study tours are also included in the programme.

The work programme is guided by a grower-led Management Group that includes members of the BPOA Technical Committee

This is the Bedding and Pot Plant Centre report for Objective 4. Adopting new responsibly sourced growing media blends. It reports trials carried out at 1. Hills Plants (Pot Plants) and 2. Earley Ornamentals (Propagation).

Background

Sectors within the horticulture industry that specialise in containerised plant production (e.g. bedding and pot plants, and hardy nursery stock) are the largest professional users by volume of peat-based growing media. Research carried out as part of CP 100 'Tracking Peat usage in Growing Media Production' showed that 60.6 % of peat sales in 2015 were in this sector. Research work on growing media amendments and alternative materials to peat (e.g. coir, bark, woodfibre and green compost) have been on-going in the horticultural industry for over 20 years, and this has led to some changes in peat-use within the industry, with some businesses now offering plants grown in 100% peat-free substrates. Latest figures from the 2020 report for CP 100 and CP 203 indicated 0.72 million m³ of peat used by professional growers versus 0.44 million m³ of alternative materials. A significant number of nurseries have now reduced the amount of peat in their growing media by 10-50% (standard in bedding and hardy nursery stock is currently 70% peat, 30% alternatives), and alternative materials are used exclusively on a commercial scale in some sectors, such as coir in the soft fruit industry.

In 2011, Defra introduced a voluntary target for amateur gardeners to phase-out the use of peat by 2020, and a final voluntary phase-out target of 2030 for professional growers of fruit, vegetables and plants. In December 2021, Defra announced plans to ban the use of peat in the amateur sector in England and Wales by the end of this Parliament and has been consulting on the phasing out of peat in the professional sector. The reduction of peat use in horticulture is expected to be achieved by using a blended range of materials rather than relying solely on one or two main ingredients, not least due to availability of alternative materials.

Where proprietary peat-free growing media blends have been used with some success on nurseries, the need to optimise irrigation, nutrition and mechanisation have been highlighted as areas where further support is required by the industry to get the best out of those blends and increase grower confidence.

A series of demonstration trials has been carried out at various grower sites over two years, under the Bedding and Pot Plant Centre. This trial programme demonstrates the use of peat-free growing media in pot plants (Hills Plants), propagation (Earley Ornamentals and Arden Lea Nurseries) and bedding plants (Arden Lea). Grower inputs (standard irrigation, liquid feeding and pesticide applications) along with mechanisation considerations will be monitored and adjusted as necessary to achieve a marketable crop and will help to determine the adjustments growers need to be made when using peat-reduced and peat-free growing media. Workshops will be hosted at the grower sites to enable attendees to view the trials, learn about the cultural inputs and any amendments required, and ultimately increase grower confidence in the uptake of responsibly sourced growing media blends.

Project objectives

Objective 1: To evaluate nursery standard irrigation requirements for bedding and pot plant propagation and production using up to three proprietary peat-reduced and peat-free growing media products on up to four UK nurseries.

Objective 2: To evaluate the need for any adjustments to liquid feed applications for bedding and pot plant production using up to three proprietary peat-reduced and peat-free growing media products under standard nursery irrigation.

Objective 3. To identify any adjustments required to the standard nursery tray/pot/pack filling machine practices when using proprietary peat-reduced and peat-free growing media products.

Methods and materials

1. Hills Plants (Pot Plants)

Site and crop production details

This trial was set up at Hills Plants, Runcton, Chichester on 29 September 2021 (week 39). Plugs of two pot plant species (*Calathea roseopicta* ‘Silvia’ and *Ficus benjamina* ‘Exotica’) were potted into three peat-free substrates provided by different manufacturers, and a peat-based product (13 cm pots) and grown on under glass until the final assessment on 19 January 2022 (**Figure 6**). The *Calathea* and *Ficus* were selected for this trial because *Calathea* don’t like to be too dry on capillary matting, and *Ficus* tends to show nutritional problems easily. All

plants were potted by hand. Benches were lined with capillary matting and black plastic to enable ebb and flood irrigation. Irrigation and feeding regime followed Hills standard practice, with any effects on plant quality recorded. Nursery standard practices were used for pest and disease control. Inspections and assessments are summarised in **Table 1**.



Figure 6. Growing media trial set up, Hills Plants, Chichester, 29 September 2021

Preventative pest control measures were applied as follows:

- Sciarid fly larvae: Nemasys F (*Steinernema feltiae*). Applied one week after potting
- Slugs: Nemaslug (*Phasmarhabditis californica*). Applied one week after potting
- Sciarid fly / shore fly: *Stratiolaelaps scimitus* (*Hypoaspis miles*)
- Two-spotted spider mite: *Phytoseiulus persimilis*
- Western flower thrips: *Neoseiulus cucumeris* (*Amblyseius cucumeris*)

Temperature and humidity were monitored throughout the trial using two Tinytag data loggers.

Trial design and statistical analysis

This was a non-replicated, non-randomised demonstration trial, with no statistical analysis. This simple trial design allowed for ease of crop management in terms of irrigation and feeding, and plants were grouped by growing media treatment, with different coloured labels to distinguish each growing media. For each plant species three peat-free blends were compared a peat-based product (control); this provided four demonstration plots per crop, with 64 plants of each species pots per growing media blend, and a total of 512 plants in total.

Table 1. Hills Plants. Summary of trial inspections and assessments, 2021-22

Date	Week no.	Action	Assessment
29/09/2021	39	Plants transplanted; trial set up	Root development, plant quality, plant height (cm)
19/01/2022	3	Assessment	Plant height (mm), root quality, plant quality, Growing media samples for analysis. Fresh and dry weights sampled.

2. Earley Ornamentals (Propagation)

This propagation phase trial was set up at Earley Ornamentals, Thirsk on 05 January 2022 (week 1). Seeds of seven plant species (*Antirrhinum* 'Sonnet', Geranium 'Horizon', African Marigold 'Antigua', *Mimulus* 'Mystic', Pansy 'Premier', *Petunia grandiflora* 'Espresso Grande', and *Cosmos* 'Sonata White'), and cuttings of *Senetti* 'Deep Blue' were sown / stuck into two peat free substrates and a peat-based growing media provided by different manufacturers to suit plug production and grown on under glass until the final assessment on 15 February 2022. Tray sizes were 480 plugs (*Antirrhinum*, African Marigold, *Mimulus*, Pansy, *Petunia* and *Cosmos*), 360 plugs (Geranium) and 84 plugs (*Senetti*). Seeds were machine-sown, and cuttings were stuck by hand. Benches were open mesh (**Figure 7**), and the irrigation and feeding regime followed Earley Ornamentals' standard practice, with any effects on plant quality recorded. Irrigation was via boom and lance. Nursery standard practices were used for pest and disease control. Inspections and assessments are summarised in **Table 2**.

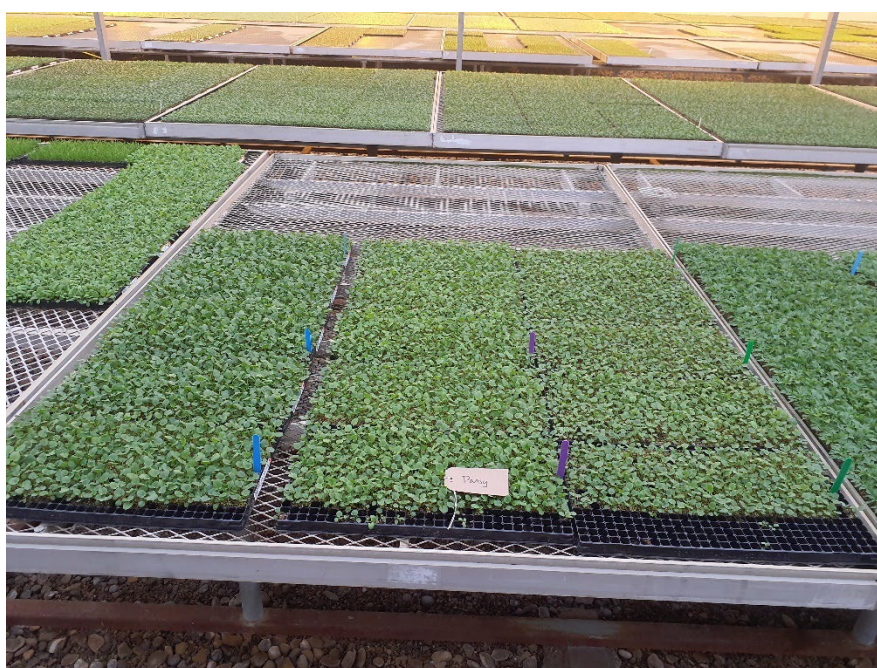


Figure 7. Earley Ornamentals. Growing media trial (Pansy), 05 January 2022

No pesticides were applied during this trial.

Trial design and statistical analysis

This was a non-replicated, non-randomised demonstration trial, with no statistical analysis. This simple trial design allowed for ease of crop management in terms of irrigation and feeding, and plants were grouped by growing media treatment, with different coloured labels to distinguish each growing media.

For each plant species two peat-free blends were compared with a peat-based product; this provided three demonstration plots. There were twelve trays per plant species, providing four trays per growing media blend. Larger plug sizes were used for the *Senetti*, *Geranium* than the remaining six species. Per growing media blend, there were four trays of 480 plugs, totalling 1920 plugs for each of *Antirrhinum*, *African Marigold*, *Mimulus*, *Pansy*, *Petunia* and *Cosmos*; four trays of 360 plugs, totalling 1440 plugs for the *Geranium*; and four trays of 84 plugs, totalling 336 plugs for the *Senetti*. This provides a total of 39888 plugs.

Table 2. Earley Ornamentals. Summary of trial inspections and assessments, 2022

Date	Week no.	Action	Assessment
05/01/2022	1	Plants transplanted and trial set out	Growing media samples for analysis.
15/02/2022	7	Assessment	Plant height (mm), root quality, plant quality. Fresh and dry weights sampled.

Assessments (Hills Plants and Earley Ornamentals trials)

Inspections and assessments are summarised below.

- Nutrient analysis (NRM) of growing media samples was carried out at the start and end of the demonstration trial.
- Pot fill assessment at the start of the demonstration trial.
- Grower comments on irrigation frequency, liquid feeding, pesticide applications and general crop husbandry were recorded.

At the end of the trial:

- Commentary on plant quality.

- Plant height. 20 plants per growing media treatment, per species, at the end of the demonstration.
- Root development. 20 plants per growing media treatment per species at the end of the demonstration on a scale of 0 – 4 (**Table 3**).
- Temperature and humidity were recorded throughout the trial.
- Fresh and dry weights.

Table 3. Root development scores

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 100% of pot

Results

1. Hills Plants (Pot Plants)

The effect of each treatment on the height, plant and root quality, fresh and dry weights of the two plant species produced in the peat-free growing media was compared with those produced in the peat-based growing media. Plant height, root quality and fresh and dry weights of *Calathea* ‘Silvia’ and *Ficus benjamina* ‘Exotica’ are tabulated in **Table 4** and **Table 5** respectively. Growing media analyses are presented in Error! Reference source not found., with images showing the four substrates, and plant and root quality at the end of the trial in **Appendix 2** and **Appendix 3** respectively. Commentary from Hills Nursery on management and plant development are presented in **Table 6**. This was a non-replicated, non-randomised demonstration trial, and no formal statistical analysis was undertaken.

All plants obtained for the trial were of good quality with well-established root systems prior to transplant.

Mechanisation / pot fill assessment

The peat-based growing media was generally a fine grade, but with some woodfibre pieces 1-2 cm long, and with perlite present (**Appendix 2**), however, Treatments A, B and C were a fine grade. Treatment B was damper than the others, and initially became stuck in the pot filling machine (so that the first pots were not fully filled), before achieving an appropriate flow

rate and there were no further issues with potting. Pots were hand-filled with treatments A and C.

Plant quality. An ebb and flood irrigation system was used on the nursery, and it was not possible to isolate the trial plants from the commercial crop. The peat-based growing media held more water than treatments A-C. The *Calathea* did not respond as well to these wetter conditions, and plant quality was adversely affected, with plants exhibiting poor development and leaf scorch (**Appendix 4a**). No leaf yellowing was recorded on any of the *Ficus* (**Appendix 4b**).

Plant height, root quality, fresh and dry weights. For plant height, *Calathea* in treatment A were the tallest, with the greatest fresh weight and dry weight, while greater root development was recorded for plants in treatment C. Plants grown in the peat-based growing media were shorter, with poorer root development, lower fresh and dry weights than all other treatments (**Table 4, Figure 8**).

Table 4. Hills Plants. *Calathea* 'Silvia'. Average plant height, root development scores (scale of 0-4; 0= no roots; 4 = 100% of pot), fresh (FW) and dry (DW) weights at the final assessment (19 January 2022).

Treatment	Average height	Average root development	Average FW (g)	Average DW (g)
Peat-based	129.6	2.2	9.0	1.2
A	193.0	3.6	23.8	2.1
B	169.0	3.0	20.7	2.0
C	177.3	3.7	21.7	2.1



Figure 8. Hills Plants. *Calathea* 'Silvia'. Comparative image, 19 January 2022. Peat-based growing media (blue labels), treatment A (yellow labels), treatment B (purple labels) and treatment C (green labels)

However, the tallest *Ficus* were produced in treatment B, and the greatest fresh and dry weights were recorded for plants grown in the peat-based growing media. The shortest plants

were produced in treatment A. There were no differences between treatments for root development (**Table 5, Figure 9**).

Table 5. Hills Plants. *Ficus benjamina* 'Exotica'. Average plant height, root development scores (scale of 0-4; 0= no roots; 4 = 100% of pot), fresh (FW) and dry (DW) weights at the final assessment (19 January 2022).

Treatment	Average height	Average root development	Average FW (g)	Average DW (g)
Peat-based	464.3	4.0	29.2	6.8
A	439.3	4.0	25.4	5.7
B	476.3	4.0	24.8	5.6
C	473.6	4.0	25.0	5.6



Figure 9. Hills Plants. *Ficus benjamina* 'Exotica'. Comparative image, 19 January 2022. Peat-based growing media (blue labels), treatment A (yellow labels), treatment B (purple labels) and treatment C (green labels)

Growing media analyses

Growing media analyses are presented in **Appendix 2**. Growing media analysis (NRM) carried out at the start of the trial indicated that the EC was considered high for use in pot plant production for treatment B (647 $\mu\text{S}/\text{cm}$). A further analysis was carried out at the end of the trial for the *Ficus* which indicated that the EC had increased in all treatments although to differing degrees, with the highest EC recorded for treatment C; high Cl and K will have contributed to this. However, the plants were not showing any adverse effects because of the high EC, and no adjustments to the nutrient regime were necessary.

Grower commentary

Grower comments on how each of the growing media performed within the trial, and how this affected plant development are presented in **Table 6**.

Table 6. Hills Plants. Grower comments, four weeks after potting

Treatment	Comments
Peat-based growing media	This substrate was less well drained than other treatments, with waterlogging observed and poor root development. Top growth was relatively consistent across all treatments
Treatment A	By four weeks after potting, plants in Treatment A had good root growth on both the <i>Calathea</i> and <i>Ficus</i> ; <i>Ficus</i> roots encircled the root ball. Plants in this treatment rooted before those in other treatments.
Treatment B	The growing media was less well drained than some other treatments, holding onto water so that the substrate was dense, wet, and heavy compared with all other treatments. Roots were less well developed than treatments A and C. Shore flies were present in Treatment B, an indication of the wetter nature of this growing media.
Treatment C	This growing media was well drained, encouraging healthy root growth. A good root structure had developed with healthy white roots encompassing the root ball.

2. Earley Ornamentals (Propagation)

The effect of each treatment on the height, plant and root quality, fresh and dry weights of the eight plant species produced in the peat free growing media was compared with those produced in peat-based growing media. Plant height, root quality and fresh and dry weights of each species are tabulated in **Table 7**. Growing media analyses are presented in **Appendix 4**, with images showing the three substrates (**Appendix 5**), root quality (**Appendix 6**) and plant quality (**Appendix 7**) at the end of the trial. Earley Ornamentals commentary on plant management and plant development are presented in Error! Reference source not found.. This was a non-replicated, non-randomised demonstration trial, and no formal statistical analysis was undertaken.

Tray fill assessment

Treatment B was moister than the peat-based growing media and Treatment C, but it still flowed well through the tray filling machine, if slightly slower than Treatment C, and trays were filled consistently well by both treatments. In general, the particle size in both Treatment B and Treatment C was small enough for the cells in the 480 trays, except that Treatment C had some fibrous material that was at times too long (**Appendix 5**), overhanging the sides of the cells and giving rise to concerns that it could catch on other plants when moved and then dislodge some of the growing media.

Plant quality. All plants assessed for plant quality were marketable, achieving scores of 3 to 5 (**Table 7, Appendix 7a**). A score of 5 (excellent quality, no damage visible) was recorded for plant quality for all species in the peat-based media, for the *Senetti*, *Mimulus*, *Cosmos* and Geranium in Treatment B, and for the *Senetti*, *Petunia*, Geranium, and the African Marigold in Treatment C. All species scored 4 and above when grown in Treatment B. The lowest scores were achieved by the *Mimulus*, Pansy and *Antirrhinum* grown in Treatment C, scoring 3.

The grower had ‘gapped’ the plug trays where seedlings were undersize or had not survived, and this showed differences between species in the number of plants that germinated and established (**Appendix 7b**). The *Mimulus*, *Petunia* and *Antirrhinum* established well with minimal losses. The *Cosmos* and The African marigold appeared most sensitive to the treatments, with most losses in Treatment C and fewest in the peat-based growing media. *Cosmos* similarly had most losses in Treatments B and C.

Plant height. There was no trend to link plant height to any specific growing medium (**Table 7**). The peat-based growing media produced the tallest *Cosmos*, Pansy, *Petunia*, Geranium and *Antirrhinum*. Treatment B produced the tallest *Mimulus* only, while the *Senetti* and African Marigold were taller when grown in treatment C.

Root quality was consistently good across all growing media for all species, barring the *Antirrhinum* in treatment B (score 3) and the *Antirrhinum* and *Petunia* in Treatment C (score 3), where the roots were less well developed (**Table 7, Figure 10**). The plugs tended to hold together well when grown in the peat-based growing media, but also in Treatment B. There was a tendency for the plug to crumble for some species in Treatment B (*Petunia* and *Antirrhinum*), and more so in Treatment C (*Mimulus*, *Petunia*, and Geranium) (**Appendix 6**), but this was linked to plug integrity rather than root quality as these species all scored 3 or 4 for root quality.



Figure 10. Earley Ornamentals. Root quality: *Antirrhinum* 'Sonnet' (left) and *Petunia grandiflora* 'Espresso Grande' (right). Peat-based growing media (blue labels), treatment B (purple labels) and treatment C (green labels), 15 February 2022

Fresh and dry weights

The plants with the greatest fresh rate for all species were produced in either Treatment A or Treatment C (**Table 7**). Treatment A produced Mimulus, Pansy, Petunia, African Marigold and Antirrhinum with greater fresh weight, Treatment C the Senetti and Cosmos.

There was minimal or no difference in dry weight between treatments for the Mimulus, Cosmos, Pansy, Petunia, Geranium and Antirrhinum; slightly larger differences were found for the Senetti (0.4 g) and African Marigold (0.2 g).

Table 7. Earley Ornamentals. Mean height, mean plant quality (scale of 0-5; 0=dead, 5 = excellent quality, no visible damage), mean root quality (scale of 0-4; 0 = no root development, 4 = rooting in 100% of cells), mean fresh weight (FW) and mean dry weight (DW). End of trial assessment, 15 February 2022

Species	Treatment	Mean Height (mm)	Mean Plant Quality	Mean Root Quality	Mean FW (g)	Mean DW (g)
<i>Senetti</i> 'Deep Blue'	Peat-based	116.4	5	4	2.2	1.9
	B	110.0	5	4	2.0	1.5
	C	125.8	5	4	2.4	1.8
<i>Mimulus</i> 'Mystic'	Peat-based	22.4	5	4	3.9	0.3
	B	23.1	5	4	3.4	0.2
	C	16.4	3	4	2.6	0.2
<i>Cosmos</i> 'Sonata'	Peat-based	76.7	5	4	5.9	0.4
	B	68.8	5	4	5.7	0.4
	C	74.5	4	4	6.6	0.5
Pansy 'Premier'	Peat-based	37.9	5	4	2.9	0.3
	B	36.4	4	4	2.8	0.3
	C	28.7	3	4	2.3	0.3
<i>Petunia grandiflora</i> 'Espresso'	Peat-based	36.3	5	4	6.8	0.3
	B	31.0	4	4	4.6	0.3
	C	29.5	5	3	3.5	0.2
Geranium 'Horizon'	Peat-based	35.9	5	4	9.3	0.8
	B	35.3	5	4	9.2	0.8
	C	32.9	5	4	9.0	0.8
African Marigold 'Antigua'	Peat-based	51.2	5	4	6.5	0.6
	B	56.2	5	4	6.3	0.5
	C	57.4	5	4	6.2	0.4
<i>Antirrhinum</i> 'Sonnet'	Peat-based	36.9	5	4	2.3	0.2
	B	30.3	4	3	1.9	0.2
	C	25.7	3	3	1.6	0.1

Growing media analyses

Analyses of unused growing media, carried out at the start of the trial (NRM) are presented in **Appendix 4**. EC was high, particularly for seed production, in Treatment C, with K, Cl and sulphate the main contributors.

Grower commentary

Grower comments on how each of the growing media performed within the trial. Growers reported that there were no issues with any of the growing media during potting or seeding, even though Treatment C had some longer fibres; they were not keen on the perlite in Treatment B. The growers had not adjusted either irrigation or nutrition for any of the mixes to achieve the results presented.

The seed-raised plants were gapped up, and this provided an opportunity to see how the growing media would perform during transplants. Plugs from Treatment B did hold together but did not perform as well as the peat-based media. Plugs from Treatment C fell apart somewhat and performed the worst during gapping up.

Discussion and conclusions

1. Hills Plants (Pot Plants)

For the trial at Hills Plants, because plants across the nursery were irrigated and liquid feed applied via a single ebb and flood system it was not possible to adjust inputs to suit plants in the different treatments. However, some of the growing media included in this trial were better suited than others for use within this system, with better growth and development of plants grown in the more open and well drained growing media. It is possible to identify from these results that as the peat based growing media (and to a lesser extent treatment B) held more water than treatments A and C growers would need to adjust their irrigation, applying less water and this would have improved plant quality in the peat-based growing media. Similarly, when growing in treatments A and C the substrate provided better drainage, therefore growers would need to irrigate more often.

The increase in EC across all the growing media may be due to the amount of water and liquid feed applied, with water application managed to allow the peat-based growing media to dry back. Where water application is restricted salts can build up in the growing media if not taken up or utilised by the plants, as they are not flushed through when irrigation is applied, and this is reflected in the increased EC. Materials such as bark can provide a greater buffering effect which can help to protect plants against high salt levels.

It is also worth noting that the source of materials (e.g. manufacturer) and the way they are produced (e.g. size, how fibrous the final product is) can cause the growing media to behave

differently, particularly in terms of water holding capacity and this will affect water management requirements.

Notwithstanding the financial implications of growing in peat-free growing media compared with 100% peat, many growers have transitioned, or have started to transition, to substantially peat-reduced or peat-free substrates. However, growers that haven't made this change have voiced that they often lack the confidence and require further support to achieve this transition.

2. Earley Ornamentals (Propagation)

The high EC in Treatment C is likely to have contributed to the poorer root quality scores for *Petunia* and *Antirrhinum*. A substrate EC below 200 $\mu\text{S}/\text{cm}$ is usually recommended for seedlings, above which root damage can be caused, depending on species sensitivity. High EC can cause ex-osmosis, where water will move out of delicate roots and root hairs if the concentration of nutrients is higher in the solution around the plant roots than inside the roots. Root damage is evident as brown root tips and root dieback depending on severity. Plants can adapt to high EC by increasing the concentration of nutrients in their roots, but the extent of this adaption will be species dependent. This in turn increases the likelihood of root diseases such as *Pythium* and *Phytophthora*.

While a higher level of K alone may not cause direct plant damage, it can interact and compete with other nutrients; if K is present in excess, it may decrease uptake of N; and P, Ca and Mg. Ideal ratios of these nutrients are 1N:1K, and similarly 4K:2Ca:1Mg to prevent imbalance. Analysis of unused growing media is recommended to provide a guide to nutrient requirements during production.

For propagators, the integrity of plugs is critical to successful gapping and subsequent transplanting, and this can be a difficulty in peat-free substrates. This trial indicated that although plug integrity was best in the peat-based media, there was potential for Treatment B.

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- The BPPC Management Group for steering the project.

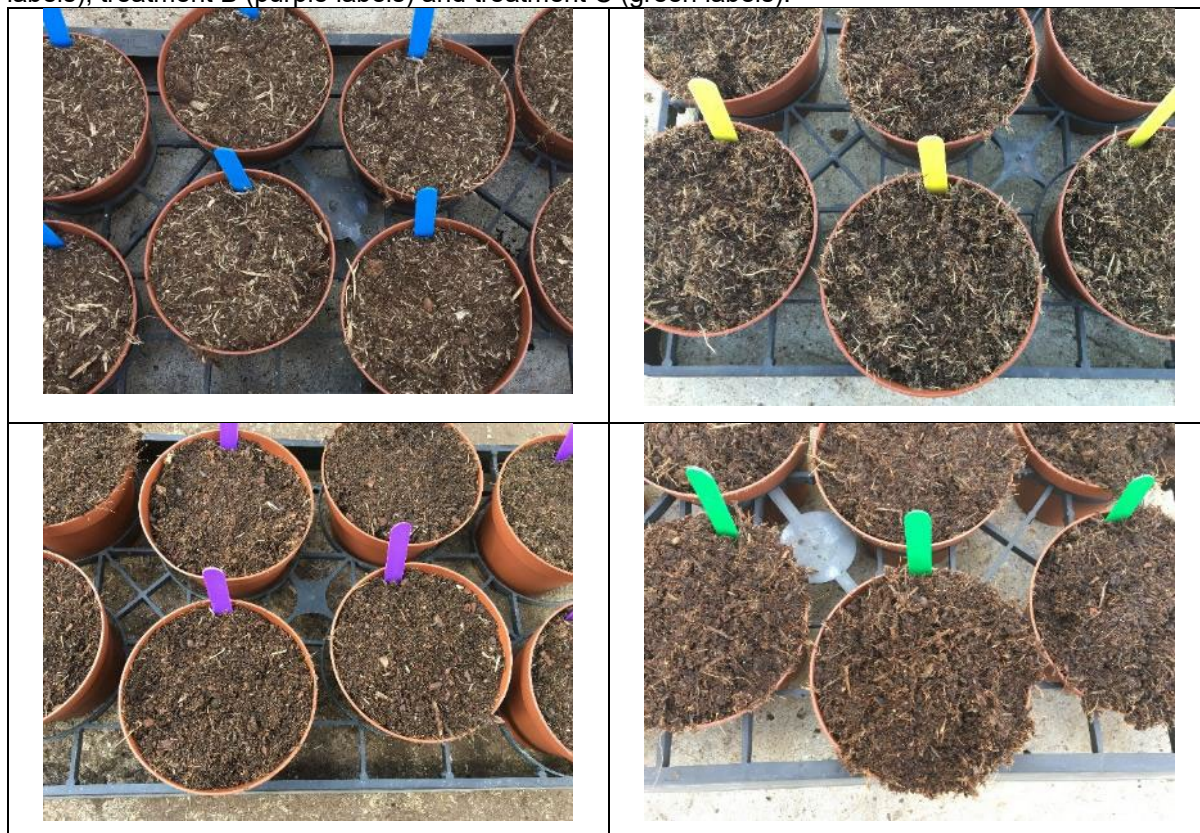
Appendix 1

Hills Plants. Initial (29 September 2021) and final (19 January 2022) growing media analyses. Growing media from pots growing *Ficus* was sampled for the final analyses.

Treatment	Analysis timing	pH	EC	NH ₃	NO ₃	Total soluble N	P	K	Mg	Ca	Na	Mn	Zn	Fe	Cl	SO ₄	B	Cu	Density	Dry Matter	Dry Density
			uS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	kg/m ³	%	kg/m ³
Nursery standard	Initial	5.5	221	21.7	10	31.7	17.9	81.4	44.6	28.4	18.8	0.33	0.38	1.43	13.4	402.4	0.15	0.08	233	80.1	186.6
	Final	5.2	780	3.3	278.4	281.6	140.2	306.4	208.9	199.9	71.7	0.92	0.04	1.59	105.8	421.5	0.92	0.04	363	29.6	107.4
A	Initial	6.5	442	4.8	92.0	96.8	25.9	352.7	27.4	54.4	73.3	0.98	0.7	1.19	91.5	369.5	0.50	0.73	343	53.4	183.2
	Final	6.5	576	1.4	208.4	209.8	74.2	398.8	56.6	128.8	81.2	<0.01	0.12	0.24	102.3	180.7	1.07	0.08	394	21.5	84.7
B	Initial	6.8	647	122.7	116.2	238.9	60.5	432.9	13.6	34.7	58.4	2.66	4.09	1.46	84.6	571.4	0.94	0.77	427	56.0	239.1
	Final	5.8	713	2.6	294	296.7	92.8	479.3	79	179.9	79.1	0.13	0.34	0.87	102.7	164.6	1.68	0.05	448	33.7	151
C	Initial	6.2	239	8.1	20.6	28.8	25.5	223.7	1.7	4.2	53.5	0.02	0.07	0.95	180.9	73	0.23	0.01	408	43.1	175.8
	Final	5.3	1102	5.6	294.1	299.7	137.2	888	101.3	137.2	215.1	0.38	0.68	2.24	613.1	184.2	0.96	0.08	388	34.9	135.4

Appendix 2

Hills Plants. Growing media samples: Peat-based growing media (blue labels), treatment A (yellow labels), treatment B (purple labels) and treatment C (green labels).

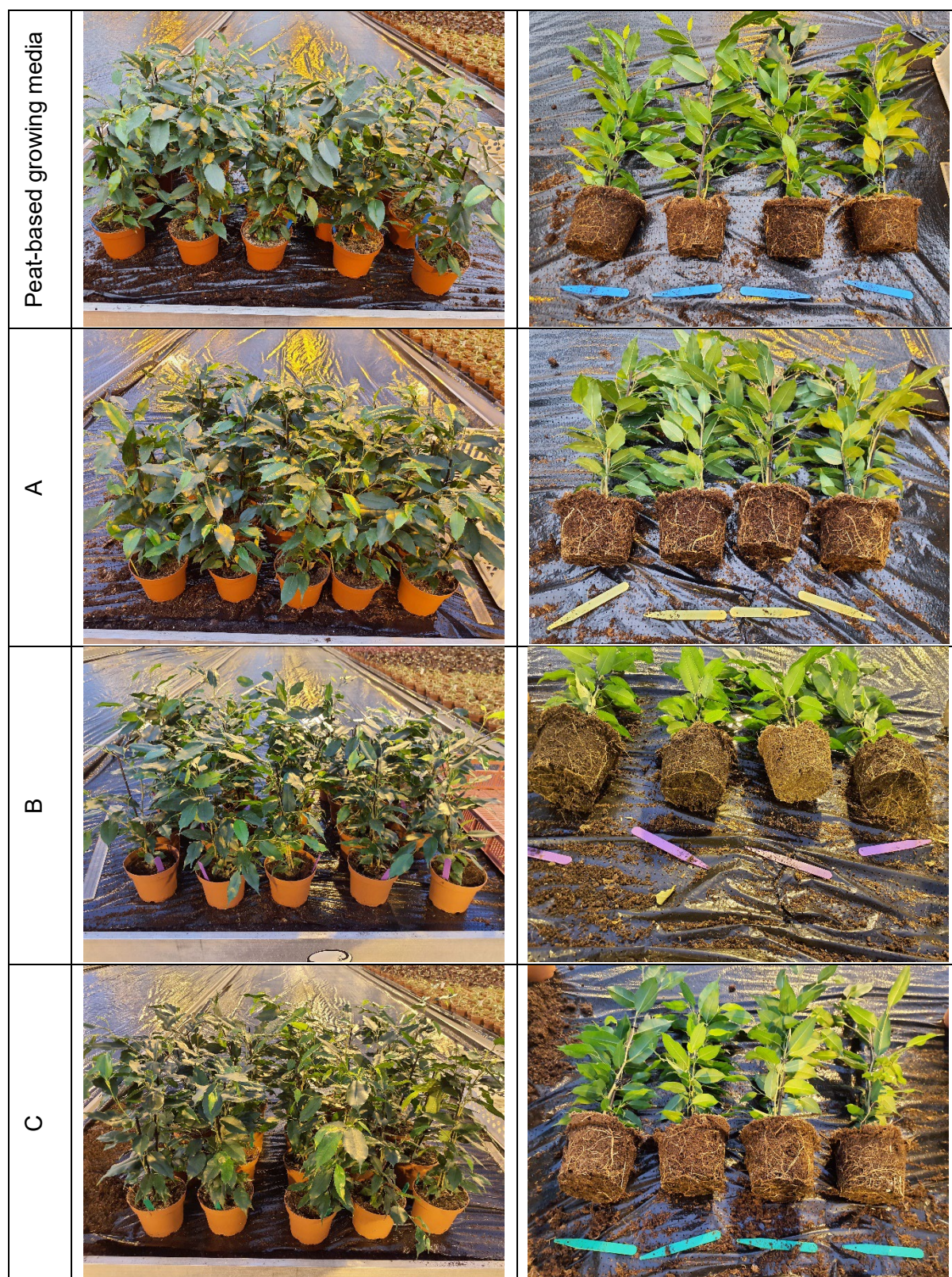


Appendix 3

- a. Hills Plants. *Calathea* 'Silvia'. Plant quality (left) and root quality (right). Peat-based growing media (blue labels), treatment A (yellow labels), treatment B (purple labels) and treatment C (green labels), 19 January 2022



b Hills Plants. *Ficus benjamina* 'Exotica'. Plant quality (left) and root quality (right). Peat-based growing media (blue labels), treatment A (yellow labels), treatment B (purple labels) and treatment C (green labels), 19 January 2022





Appendix 4

Earley Ornamentals. Unused growing media analyses (05 January 2022)

Treatment	pH	EC	NH ₃	NO ₃	Total Soluble N	P	K	Mg	Ca	Na	Mn	Zn	Fe	Cl	SO ₄	B	Cu	Density	Dry Matter	Dry Density
		uS/cm	Mg/l	Mg/l	Mg/l	Mg/l	Mg/l	Mg/l	Mg/l	Mg/l	Mg/l	Mg/l	Mg/l	Mg/l	Mg/l	Mg/l	Mg/l	Kg/m ₃	%	Kg/m ₃
Peat-based	6.1	169	26.9	42.8	69.7	17.9	79.0	22.1	34.7	17.0	0.36	0.36	28.38	24.3	132.2	0.55	0.09	283	44.3	125.4
B	6.7	159	1.9	<0.6	1.9	28.7	156.1	2.8	8.9	35.3	0.10	0.80	1.39	60.4	160.6	0.50	0.05	328	35.1	115.1
C	6.7	587	49.1	120.9	170.0	64.1	528.2	5.7	6.7	110.0	0.07	0.47	1.16	288.9	114.7	0.42	0.06	398	31.2	124.2









Appendix 5

Peat-free growing media samples filled into trays: 84 tray for cuttings (left) and 480 tray for seeds (right)

	
Treatment B	Treatment C



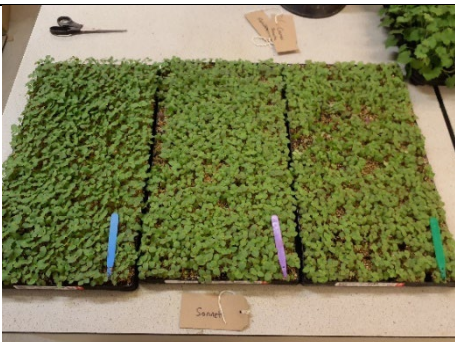
Appendix 6

Earley Ornamentals. Root quality. Peat-based growing media (blue labels), treatment B (purple labels) and treatment C (green labels), 15 February 2022

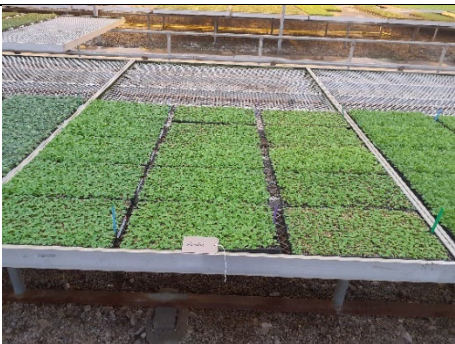


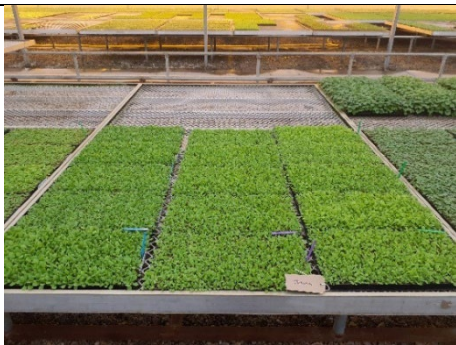
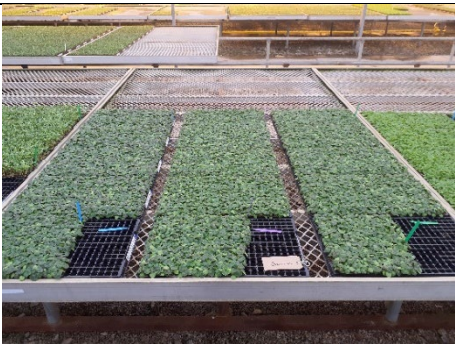


	
<p><i>Senetti</i> 'Deep Blue'</p>	<p><i>Petunia grandiflora</i> 'Espresso' mixed</p>
	
<p><i>Mimulus</i> 'Mystic' mixed</p>	<p><i>Geranium</i> 'Horizon' mixed</p>
	
<p><i>Cosmos</i> 'Sonata' mixed</p>	<p>African Marigold 'Antigua'</p>
	
<p>Pansy 'Premier' mixed</p>	<p><i>Antirrhinum</i> 'Sonnet'</p>

Appendix 7

- a. Earley Ornamentals. Plant quality. Peat-based growing media (blue labels), treatment B (purple labels) and treatment C (green labels), Senetti: 15/02/2022; seed raised species: 16/02/2022

	
Senetti 'Deep Blue'	Mimulus 'Mystic' mixed
	
Cosmos 'Sonata' mixed	Pansy 'Premier' mixed
	
Petunia grandiflora 'Espresso' mixed	Geranium 'Horizon' mixed
	
African Marigold 'Antigua'	Antirrhinum 'Sonnet'

- a. Earley Ornamentals. Germination and establishment success of seed-raised species following 'gapping up'. Peat-based growing media (blue labels), treatment B (purple labels) and treatment C (green labels), 15 /02/2022

	
<i>Mimulus</i> 'Mystic' mixed	<i>Cosmos</i> 'Sonata' mixed
	
Pansy 'Premier' mixed	<i>Petunia grandiflora</i> 'Espresso' mixed
	
Geranium 'Horizon' mixed	African marigold 'Antigua'
	
<i>Antirrhinum</i> 'Sonnet'	