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CONTRACT REPORT

Bedding Plants:
Evaluation of reduced peat or peat-free substrates

HDC PC113

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

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Final Report May 1996

HDC PC113

Bedding Plants: Evaluation of reduced peat or peat-free substrates

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Co-ordinator: Mr N Wait

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Key words: Bedding plants, growing media, coir, bark, rockwool, *Salvia, Impatiens,* Marigold, Geranium, *Petunia, Begonia.*

1. RELEVANCE TO GROWERS AND PRACTICAL APPLICATION

1.1 APPLICATION

The aim of the trial was to evaluate a range of commercially available peat-free substrates in direct comparison to the use of a peat-based growing media, Levington M2, for the production of six bedding plant species.

All substrates trialled produced plants of marketable quality at the point of sale. There were great variations in plant growth as a result of the growing practices employed, and this demonstrated the importance of tailoring watering/feeding practices to each growing media. Generally, the coir-based media grown plants were more comparable to those grown in Levington M2, under the standard cultural practices employed for the peat-based growing media. The other media types which were mainly bark/woodfibre-based materials required greater manipulation of the watering regime for plant growth and quality to be optimised.

1.2 SUMMARY

The use of peat as a growing media in commercial horticultural production has continued to face growing pressure from environmentalists because of concerns about the perceived loss of peat reserves and wildlife habitats. A range of alternative substrates are available for use in the amateur market but, as yet, few commercial growers of pot and bedding plants use peat-free growing media on a large scale.

Bedding plant producers have had little involvement with the use of peat-free media as often their use/consumption in small containers is overlooked, compared to the relatively large quantities used in Nursery Stock. However, as the multiples continue to increase their market share in bedding plant sales, their policy towards environmental issues has included moves towards reducing the use of 'non-sustainable' resources which has included the use of peat in growing media.

The aim of this study was to conduct an evaluation of alternative growing media for use in commercial bedding plant production in comparison to a standard peat-based substrate. This would provide a valuable 'independent' assessment of the materials currently available to growers. It would also aim to identify changes in cultural management which may be necessary with the use of an alternative media to peat. The trial did not set out with the aim to identify the 'best' or 'worst' performers, but to evaluate a range of alternative growing media in direct comparison to a standard peat media.

1.2.1 Methodology

Seed of each of the following species was purchased from Colegraves Seeds Ltd.

Geranium F1	Century Scarlet
Petunia F1	Express Salmon
Impatiens F1	Accent Salmon
Marigold F1	Aurora Fire
Salvia F1	Vanguard
Begonia F1	Olympia Red

Nine peat-free media types were used in comparison to a standard peat-based growing media, Levington M2.

No.	Product	Company
1.	GU/BU Rockwool Mix	Grodania A/S Wern Tarw, Pencoed, Bridgend Mid Glamorgan, CF35 6NY
2.	Coir Based (Cococompost)	Wessex Horticultural Products Ltd* South Newton, Salisbury Wiltshire, SP2 0QW
3.	Coir Based (Golden Grow Cocofibre)	William Sinclair Horticulture Ltd Firth Road, Lincoln, LN6 7AH
4.	Coir Based (Coir Potting Compost)	Roffey Bros Ltd Throop Road, Bournemouth Dorset, BH8 0DF
5.	Woodfibre and Clay Based (Sunrise 15)	Bulrush Peat Co Ltd Newferry Road, Bellaghy Magherafelt, County Derry Northern Ireland, BT45 8ND
6.	Woodfibre Based (Sylvafibre/Grobark)	Melcourt Industries Ltd Eight Bells House, Tetbury Gloucestershire, GL8 8JG

No.	Product	Company
7.	Woodfibre Based (Peat free)	Shamrock Horticulture The Crescent Centre, Temple Back Bristol, BS1 6EZ
8.	Coir/Loam Based (Peat free)	Petersfield Products 45 Cambridge Road, Cosby Leicestershire, LE9 5SJ
9.	Green - Waste Materials (Peat free)	Richmoor Horticulture** George Street, Glastonbury Somerset, BA6 9JH
10.	Levington M2 (Control)	Levington Horticulture Paper Mill Lane, Bramford Ipswich, Suffolk, IP8 4BZ

* Product supplied late into the trial and thus not used in all species x replicate blocks. Therefore, treated as an observation only.

** Product now handled by Freeland Technologies, 29 Kingfisher Way, Horsham, West Sussex, RH12 2LT.

It was not an objective of this study to directly compare the above products with each other but to carry out a preliminary assessment of their general characteristics compared to a standard control.

All plants were therefore grown as per the requirements of the control, Levington M2. This included frequency and amount of irrigation so that a true comparison could be made between the peat-free media types and the peat-based growing media under a standard production regime.

Seed of each species was sown into 286 plug trays (except Geranium which was sown in 180 plug trays) using Levington F1 growing media. Propagation temperatures maintained a base heat of 20°C. Upon emergence and establishment the glasshouse temperature was lowered to 16°C. Approximately three weeks after sowing, plug plants were fed using a 20:10:20 NPK liquid feed (75 ppm N) at every watering.

When plants reached a suitable size they were pricked off into each of the substrate treatments and grown on in one compartment of Q-Block with a base heating temperature of 14°C with vents set to open at 16°C. Approximately 3-4 weeks after pricking-off plants were liquid fed using 150 ppm N:60 ppm $P_2 0_5$ 150 ppm $K_2 0$, with pH of irrigation water corrected to pH 6.5.

Up until the first set of records after 3-5 weeks (mid-crop) all plants received the identical watering regime as per the control, Levington M2. After the first set of assessments, half the

plants continued to receive these treatments, whilst the other half was separated so that each media type could be watered/fed when it was required on an individual basis.

Samples from each of the growing media treatments were taken at the start of the trial, at 3-5 weeks post pricking-off (mid-crop) and at marketing. Samples of leaf tissue were taken from each species x growing media at marketing.

Plant growth measurements were taken at mid-crop, immediately prior to the start of liquid feeding, and then again at maturity (marketing stage).

Observations were made of plant quality for a period of 7 days in 'shelf-life' whilst plants were held on a danish trolley under glass. Garden performance observations were made 2, 4 and 8 weeks post planting.

1.2.2 Results

It was evident on receipt of each product that the peat-free alternatives could be divided mainly between coir-based and woodfibre (bark)-based materials. In addition there was a rockwool-based and green waste based material. Their structure and ease of handling had an impact on box filling (which was done manually). The bark-based materials were generally heavier, particularly Bulrush which had to be handled manually in smaller volumes. The rockwool material was awkward to handle and care was required when box filling to ensure even 'compactness' of material in each cell. It was also very lightweight. The other materials used were generally similar to Levington M2 in their handling, although with pure coir mixes (eg. Wessex) care was needed not to over-compress the media when box filling.

Under the standard cultural regime employed (based on the requirements for Levington M2), plant growth varied widely between the different peat-free growing media. Plants grown in the coir-based materials were generally more comparable to those grown in Levington M2, whilst plants grown in the bark-based mixes were smaller and 'harder' in their appearance. SHL, Roffey and Petersfield mixes had plants of greater size and vigour in comparison to the other peat-free mixes and were comparable to the control. Plants grown in Bulrush, Melcourt and Freeland were visibly smaller. Leaf tissue analysis did not show any element deficiencies at this stage in growth, with the exception of plants grown in Wessex which appeared paler and had a reduced nitrogen content. This media type had a lower nitrogen base at pricking-off, and earlier liquid feeding would have been necessary to avoid nitrogen depletion. In general, the level of nutrients in the peat-free media were similar to that of the control, Levington M2. The exceptions were in Bulrush which had lower P and K levels, whilst SHL and Freeland were lower in N at this stage.

After mid-crop records were completed the trial was divided so that half the plants received a standard watering/feeding regime as used for Levington M2, whilst the remainder of plants/media type were treated independently with the aim of optimising the watering requirement for each substrate.

Plant growth records at marketing demonstrated how the use of different watering practices could greatly influence the performance of each media type and subsequent plant growth and quality. The coir-based materials continued to perform more favourably, and comparable to the control, Levington M2, with the exception of Petersfield which tended to produce over-vigorous growth, with plants becoming 'leggy'. The bark-based materials improved with the use of an independent watering regime whilst those grown under a standard watering regime remained more compact and their growth appeared 'harder'. This was seen as an advantage in the case of *Petunia* which acquired a better habit and quality in these media types.

In shelf-life observations, plants which were grown in the bark-based materials were better able to withstand periods of dryness, and also their compact habit meant that more plants could be accommodated on a danish trolley. The coir-based substrates needed to be kept uniformly moist otherwise plants would suffer from short periods without moisture/watering.

In garden performance assessments there were no obvious trends apparent, although the type of plant growth produced i.e. compact or 'leggy' affected plant susceptibility to damage through wind and rain.

1.3 CONCLUSIONS

- Peat-free media are now available which can be successfully used in the commercial production of bedding plants.

- Each media type would require changes to traditional cultural practices to optimise their performance for plant growth. This may be either as altered watering frequency and/or change in supplementary liquid feeding regimes.

- Costs of peat-free growing media are dropping and are becoming more comparable to peat-based growing media.

- Some peat-free growing media can have beneficial effects in plant production: coir appeared to facilitate earlier root vigour and establishment whilst the bark-based media appeared to have a greater buffer capacity between wet and dry waterings.

- Growth of plants in different media types can influence shelf-life and subsequently quality of the plant.

2. EXPERIMENTAL SECTION

2.1 INTRODUCTION

The use of peat as a growing media in commercial horticultural production has continued to face growing pressure from environmentalists because of concerns about the perceived loss of peat reserves and wildlife habitats. A range of alternative substrates are available for use in the amateur market but, as yet, few commercial growers of pot and bedding plants use peat-free growing media on a large scale.

Much research has been conducted on the use of alternative substrates within the Nursery Stock sector, but few have consistently performed well in trials and peat still remains the main component of growing substrate. However, continuing research is providing viable alternative media for use by commercial growers. Bedding plant producers have had little involvement with the use of peat-free media as often their use/consumption in small containers is overlooked, compared to the relatively large quantities used in Nursery Stock. However, as the multiples continue to increase their market share in bedding plant sales, their policy towards environmental issues has included moves towards reducing the use of 'non-sustainable' resources which has included the use of peat in growing media.

Throughout the UK and European markets, consumers are increasingly concerned with the 'greenness' of products and their effect on the environment. Large retailers, including the multiples within the UK, are trying to ensure that the products they supply are, as far as possible, grown without harm to the environment. Much attention has been focused on the use of chemicals (pesticides, fungicides, etc.) and the use of peat is being reviewed. Many retailers accept that it may not be possible to replace peat completely but would like to ensure that as much as possible is done to reduce the use of 'non-sustainable' resources.

The aim of this study was to conduct an evaluation of alternative growing media for use in commercial bedding plant production in comparison to a standard peat-based substrate. This would provide a valuable 'independent' assessment of the materials currently available to growers. It would also aim to identify changes in cultural management which may be necessary with the use of an alternative media to peat. The trial did not set out with the aim to identify the 'best' or 'worst' performers, but to evaluate a range of alternative growing media in direct comparison to a standard peat media.

Six bedding plant species were grown in nine different peat-free substrates, and their growth and management compared directly to plants grown in a standard peat-based media, Levington M2.

2.2 OBJECTIVES

- To evaluate a range of alternative peat-free growing media in the commercial production of bedding plants in comparison to a standard peat-based growing media.

- To identify any changes which may be necessary in their cultural management in comparison to a peat-based growing media.

- To determine if the use of different media types under a standard cultural regime used with a peat-based growing media would cause any nutrient disorders.

- To examine the use of different media types on the 'shelf-life' and subsequent garden performance of plants.

- To provide a 'cost-benefit' analysis for production using a peat-free growing media.

2.3 MATERIALS AND METHODS

2.3.1 Site

Seed of each species were propagated in the glasshouse facility H-Block at HRI Efford, on heated benches. Plants were pricked-off and grown-on on the floor in one compartment of the glasshouse Q-block.

2.3.2 Start Materials

Seed of each of the following species was purchased from Colegraves Seeds Ltd.

Geranium F1	Century Scarlet
Petunia F1	Express Salmon
Impatiens F1	Accent Salmon
Marigold F1	Aurora Fire
Salvia F1	Vanguard
Begonia F1	Olympia Red

2.3.3 Treatments

Nine peat-free media types were used in comparison to a standard peat-based growing media, Levington M2.

No.	Product	Company
1.	GU/BU Rockwool Mix	Grodania A/S Wern Tarw, Pencoed, Bridgend Mid Glamorgan, CF35 6NY
2.	Coir Based (Cococompost)	Wessex Horticultural Products Ltd* South Newton, Salisbury Wiltshire, SP2 0QW
3.	Coir Based (Golden Grow Cocofibre)	William Sinclair Horticulture Ltd Firth Road, Lincoln, LN6 7AH
4.	Coir Based (Coir Potting Compost)	Roffey Bros Ltd Throop Road, Bournemouth Dorset, BH8 0DF
5.	Woodfibre and Clay Based (Sunrise 15)	Bulrush Peat Co Ltd Newferry Road, Bellaghy Magherafelt, County Derry Northern Ireland, BT45 8ND

No.	Product	Company
6.	Woodfibre Based (Sylvafibre/Grobark)	Melcourt Industries Ltd Eight Bells House, Tetbury Gloucestershire, GL8 8JG
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9.	Green - Waste Materials (Peat free)	Richmoor Horticulture** George Street, Glastonbury Somerset, BA6 9JH
10.	Levington M2 (Control)	Levington Horticulture Paper Mill Lane, Bramford Ipswich, Suffolk, IP8 4BZ

* Product supplied late into the trial and thus not used in all species x replicate blocks. Therefore, treated as an observation only.

** Product now handled by Freeland Technologies, 29 Kingfisher Way, Horsham, West Sussex, RH12 2LT.

It was not an objective of this study to directly compare the above products with each other but to carry out a preliminary assessment of their general characteristics compared to a standard control.

All plants were therefore grown as per the requirements of the control, Levington M2. This included frequency and amount of irrigation so that a true comparison could be made between the peat-free media types and the peat-based growing media under a standard production regime.

2.3.4 Experimental Design

Blocks of each treatment media were replicated and positioned in the glasshouse to eliminate any effects of north-south orientation. The species were arranged in discrete rows with the media treatments randomised within each replicate. Layout of plants/treatments is given in Appendix I, page 39.

10 substrates (inc. control, Levington M2)
x
6 species
x
2 replicates*

120

Each plot consisted of 9 double-six boxes arranged 3 x 3 with the central pack of 12 plants being recorded; two replicates, total 24 plants recorded per treatment.

* After the first set of records were completed (mid-crop records) on the advice of the Grower Co-ordinator and agreed with the Vice Chairman of the BBPPA Technical Committee, the replicates were separated so that replicate 1 continued to be treated as per the control, Levington M2, whilst replicate 2 received irrigations as each treatment required.

2.3.5 Cultural Details

Seed of each species were sown into 286 plug trays (except Geranium which was sown in 180 plug trays) using Levington F1 growing media. Dates of sowing each species and germination are given in the Crop Diary, Appendix II, page 40.

Propagation temperatures maintained a base heat of 20°C. Upon emergence and establishment the glasshouse temperature was lowered to 16°C. Approximately three weeks after sowing, plug plants were fed using a 20:10:20 NPK liquid feed (75 ppm N) at every watering.

When plants reached a suitable size they were pricked-off into each of the substrate treatments and grown on in one compartment of Q-Block with a base heating temperature of 14°C with vents set to open at 16°C. Approximately 3-4 weeks after pricking-off plants were liquid fed using 150 ppm N:60 ppm $P_2 0_5$ 150 ppm $K_2 0$, with pH of irrigation water corrected to pH 6.5.

With the exception of Geranium, no chemical plant growth regulators were used. *Chlormequat* as Cycocel was applied to Geranium prior to pricking-off. Dates of application are given in the Crop Diary, Appendix II, page 40.

Up until the first set of records after 3-5 weeks (mid-crop) all plants received an identical watering regime as per the control, Levington M2. After the first set of assessments, replicate 1 continued to receive these treatments, whilst replicate 2 was separated so that each media type could be watered when it was required on an individual basis.

Pest and disease control measures are given in the Crop Diary, Appendix II, page 40.

2.3.6 Assessments

Growing Media Analysis

Samples from each of the growing media treatments were taken at the start of the trial, at 3-5 weeks (first assessment - mid crop records) and at marketing for each species. Samples were taken from replicate one plots.

Leaf Tissue Analysis

Samples from each species x growing media were taken at marketing and assessed for levels of N, P, K, Mg, Ca and Mn. Samples were taken from replicate one plots.

Plant Growth Measurements

At 21-35 days post pricking-off (dependent upon species)
Percentage cover score* (1-5; 1 = 0-20%, 2 = 21-40%, 3 = 41-60%, 4 = 61-80%, 5 = 81-100%)
Plant height* (from base of plant to top of foliage canopy)
Plant quality score (0-2; 2 = best)
Foliage colour score (0-3; 3 = darker foliage)
Rooting score (0-3; 3 = most rooting)

* as appropriate for each species

At marketing
Plant height
Plant quality score (0-2; 2 = best)
Foliage colour score (0-3; 3 = darker foliage)
Rooting score (0-3; 3 = most rooting)
Plant fresh weight and percentage dry matter (as a mean of 12 plants)

Shelf-life
Observations of plant quality were recorded after 7 days in shelf-life; during which plants were held for 7 days on a danish trolley under glass.

Garden Performance
Observations were made 2, 4 and 8 weeks post planting for assessment of plant establishment, vigour and overall appearance.

2.3.7 Statistical Analysis

Statistical analysis was limited as the size of the trial did not allow for complete replication of all treatments. Where possible data were analysed using standard Analysis of Variance (ANOVA) or Regression analysis. The degrees of freedom (d.f.), standard error (SED), and probability (P) on which the significance tests were based are presented where appropriate in the tables to aid interpretation of the results. Statistical terms referred to are:

SED = The standard error of the difference when comparing two figures in that column of data.

LSD = The least (minimum) difference when comparing two figures within a column that is required for the means to be statistically different.

P = The likelihood that the result was obtained by chance and hence not a true treatment effect.

P	=	<0.1	=	1 chance in 10
P	=	<0.01	=	1 chance in 100
P	=	<0.001	=	1 chance in 1000

NS = Not significant

3. RESULTS

3.1 Mid-Crop Records

Although species specific, an example of the scoring system used for percentage cover, rooting score and foliage colour is illustrated for *Impatiens*, Plate 1, Appendix III, page 41.

3.1.1 Geranium

The results are summarised in Table 6, Appendix IV, page 42.

Percentage Cover: The media types SHL, Roffey and Petersfield had significantly greater plant cover per box in comparison to the other peat-free media types, and were comparable to the control, Levington M2. Plants in the media Bulrush, Melcourt and Freeland were visibly smaller.

Rooting Score: Similarly as the cover score, SHL, Roffey and Petersfield had significantly greater root visible in comparison to the other media types, and comparable to the control, Levington M2. Bulrush, Melcourt and Freeland had considerably less visible root.

Plant Quality: This assessment was subjective and based on the overall appearance of the plants in terms of plant habit, size, colour and uniformity.

All plants were of an acceptable quality, although the smaller plants in Bulrush, Melcourt and Freeland were marked down as a result.

Foliage Colour: Petersfield produced plants with the darkest leaf colour, whilst all other plants were of good colour. None showed any obvious yellowing.

Fresh Weight: Records of fresh weight reflected the increase in plant size and vigour recorded visually. SHL, Roffey and Petersfield recorded the highest fresh weights for the mean of 12 plants (1 box). Rockwool also produced plants comparable to the control, whilst the other media types had plants of smaller fresh weight.

Percentage Dry Matter: Plants grown in the media Freeland had the highest percentage dry matter, 19.6%. Plants grown in SHL and Petersfield mixes were very similar in their percentage dry matter to the control, Levington M2, with a figure of 14%, 14.4% and 14.1% respectively.

3.1.2 *Salvia*

Results are summarised in Table 7, Appendix IV, page 43 and colour plates 2 to 4, Appendix V, pages 48-50.

Plant Height: Plants in Wessex were significantly smaller, 4.7cm in size in comparison to the control, 7.3cm. Grodan produced the tallest plants, 9.1cm, whilst the smallest plants, other than Wessex, were in Bulrush and Melcourt, at 6.1cm and 6.2cm respectively.

Rooting Score: Plants grown in Grodan, SHL and Petersfield media had significantly more visible roots in comparison to the control, Levington M2. Wessex produced plants with the least rooting with a score of 1.00.

Plant Quality: With the exception of plants grown in Melcourt and Freeland media types, all other media treatments produced plants of comparable quality to the control, Levington M2. Plants grown in Melcourt and Freeland were 'harder' in their appearance and not as 'lush'. Plants grown in Wessex were much smaller in their size and showing signs of obvious yellowing.

Foliage Colour: The palest plants were produced in the media Wessex. Grodan and Freeland, which although not obviously yellowing were paler in colour in comparison to plants grown in Levington M2.

Fresh Weight: Plant fresh weight records were highest for the plants grown in SHL, Roffey, Petersfield and Rockwool. All had higher fresh weights than the control. Bulrush, Melcourt and Freeland all produced plants of the same fresh weight, 26g, and appeared less vigorous than those grown in Levington M2.

Percentage Dry Matter: Plants grown in Bulrush and Grodan had the highest percentage dry matter, 14.9% and 14.2% respectively. Other plants had levels very close to that of the control, Levington M2, with the exception of plants in Wessex at 8.10%.

3.1.3 Marigold

Results are summarised in Table 8, Appendix IV, page 44 and colour plates 5 to 7, Apppendix V, pages 51-53.

Plant Height: Plants grown in Grodan, SHL and Petersfield mixes were significantly taller than plants grown in the other peat-free mixes, and with the addition of plants grown in Roffey and Bulrush were very similar in height to plants grown in Levington M2, control. The smallest plants were produced in Wessex.

Rooting Score: Plants grown in Grodan, Roffey, Bulrush and Petersfield mixes had the highest rooting score, with greater root vigour and were directly comparable to plants grown in peat, Levington M2. Plants grown in Wessex had significantly poorer root development.

Plant Quality: Plants grown in Wessex and Freeland mixes were of lower quality as a consequence of their smaller size and paler foliage. All other plants were of good quality and comparable to the plants grown in Levington M2, control.

Foliage Colour: Darkest leaf colour was recorded for plants grown in the media types, Bulrush, Melcourt, Shamrock and Petersfield. All were comparable to plants grown in peat, Levington M2. Plants were significantly paler in the Wessex mix.

Fresh Weight: Plant fresh weight records were highest for the products SHL, Roffey, and Petersfield. All had higher fresh weights than plants grown in peat. Lower plant fresh weights were recorded for plants grown in Melcourt, Shamrock and Freeland, with the lowest in Wessex grown plants.

Percentage Dry Matter: Plants grown in Wessex, Shamrock and Freeland had the highest percentage dry matter content, 12.1%, 12.9% and 12.5% respectively. Other plants had levels very close to that of the control, SHL and Petersfield with slightly reduced percentage dry matter.

3.1.4 *Petunia*

Results are summarised in Table 9, Appendix IV, page 45.

Percentage Plant Cover: Plants grown in SHL and Roffey mixes had reached 100% cover at this stage and all plants with exception of plants grown in Bulrush, Melcourt and Freeland were comparable to plants grown in peat, which had a cover score of 4.8, which is near to full box cover. Plants grown in Bulrush, Melcourt and Freeland were smaller and 'harder' in their appearance.

Rooting Score: Plants grown in Grodan, SHL, Roffey, and Shamrock mixes had significantly higher rooting scores than plants grown in the other media mixes, and above that recorded for plants grown in Levington M2. Poorer rooting was recorded for plants grown in Bulrush, Melcourt and Freeland.

Plant Quality: Plants grown in Grodan and Shamrock were assessed to be of significantly higher quality than plants grown in Levington M2. With the exception of plants grown in Roffey, Melcourt and Petersfield mixes, other plants were of better quality in comparison to plants grown in the control, Levington M2. Their habit and size were deemed to be of better quality at this stage in growth.

Foliage Colour: Plants grown in Shamrock and SHL media mixes had the darkest foliage colour, and with the exception of plants grown in Bulrush and Melcourt, plants grown in all of the peat-free mixes were of darker colour in comparison to plants grown in Levington M2. Plants grown in Bulrush and Melcourt appeared slightly more pale in comparison to plants grown in Levington M2.

Fresh Weight: Plant fresh weight was considerably higher for plants grown in SHL, Roffey and Petersfield mixes. Plants grown in Bulrush, Melcourt and Freeland peat-free mixes were considerably smaller in comparison to plants grown in Levington M2, with a lower fresh weight.

Percentage Dry Matter: Plants grown in Bulrush, Melcourt and Freeland mixes had the highest percentage dry matter levels; 17.0%, 16.9% and 16.5% respectively, compared to 10% for plants grown in Levington M2.

3.1.5 *Begonia*

Results are summarised in Table 10, Appendix IV, page 46.

Percentage Plant Cover: Percentage plant cover was significantly greater for plants grown in Petersfield. Plant cover was also higher for plants grown in Grodan and Roffey in comparison to plants grown in Levington M2, which had an approximate plant cover of 25%. Plants grown in SHL, Bulrush and Melcourt had less cover than those grown in Levington M2.

Rooting Score: Plants grown in Petersfield had a significantly increased rooting score in comparison to all other plants, including those grown in Levington M2. Plants grown in Roffey had a higher rooting score in comparison to plants grown in the other peat-free medias. Rooting was less for plants grown in the mixes SHL, Bulrush, Melcourt, Shamrock and Freeland at this stage in growth.

Plant Quality: There was no significant difference in plant quality between treatments. All plants were of good quality and comparable to plants grown in Levington M2.

Foliage Colour: Plants grown in Grodan, SHL, Roffey and Petersfield mixes were of darker colour in comparison to plants grown in Levington M2. The darkest foliage colour was recorded for plants grown in Petersfield, whereas the palest foliage was recorded for plants grown in Melcourt.

Fresh Weight: Plant fresh weight was considerably higher for plants grown in Petersfield in comparison to all other treatments, 111g. Fresh weight was higher for plants grown in Grodan, SHL, Roffey, Shamrock and Freeland mixes in comparison to plants grown in peat which had a fresh weight of 37g (12 plants). Plants grown in Bulrush and Melcourt were smaller in comparison to plants grown in Levington M2.

Percentage Dry Matter: Plants grown in Bulrush and Melcourt mixes had higher percentage dry matter levels; 5.0% and 5.2% respectively, compared to 4.6% for plants grown in Levington M2.

3.1.6 *Impatiens*

Results are summarised in Table 11, Appendix IV, page 47 and colour plates 8-10, Appendix V, pages 54-56.

Percentage Plant Cover: With the exception of plants grown in Bulrush, Melcourt and Freeland mixes, other plants were of comparable size and cover to plants grown in Levington M2. Plants grown in Grodan had the greatest cover score, 4.0, whilst plants grown in SHL, Roffey and Petersfield mixes had greater cover scores than plants grown in Levington M2.

Rooting Score: There was no significant difference in rooting between treatments. With the exception of plants grown in Melcourt, all other plants grown in peat-free media were comparable to or with increased rooting to plants grown in Levington M2.

Plant Quality: All plants were of good quality and there were no significant differences between treatments at this stage in growth.

Foliage Colour: All plants were of good colour. Only plants grown in Grodan and Freeland mixes were slightly paler than the other treatments.

Fresh Weight: Plant fresh weight was considerably higher for plants grown in Petersfield and Grodan in comparison to all other treatments, each at 71g. The smallest fresh weight was recorded for plants grown in Melcourt.

Percentage Dry Matter: There were no large differences in percentage dry matter between plants with the exception of plants in Grodan which had a percentage of 5.9% in comparison to all other media types which had levels of dry matter at 6.7% or greater.

3.1.7 Growing Media Analysis

Analysis of each media type was taken at potting/pricking off, and the results are summarised in Table 1.

Table 1: Summary of media analysis results at potting for each media type

	pH	P	K	Mg	Ca	Cond.^{ivity}	NO_3-N	NH_4-N
Control	5.8	89	126	83	80	352	114	47
Grodan	8.3	1	16	7	47	88	15	6
Wessex	6.2	11	188	1	9	194	1	1
SHL	6.5	74	410	8	12	440	102	70
Roffey	5.5	70	251	59	55	414	202	40
Bulrush	6.9	11	71	231	385	668	177	16
Melcourt	5.7	108	451	55	252	590	192	34
Shamrock	5.5	100	244	52	241	435	253	1
Petersfield	6.2	44	277	16	52	401	114	78
Freeland	7.6	25	588	14	89	456	106	1

Levels of **pH** were higher in the media types Grodan, Bulrush and Freeland whilst the other media types were nearer to the control, pH 5.8.

Levels of **phosphorous** were much lower in Grodan, Wessex, Bulrush and, to a lesser extent, Freeland in comparison with the control, 89 mg/l.

Potassium levels also varied greatly from Grodan (16 mg/l) and Bulrush (71 mg/l) up to 451 mg/l in Melcourt and 588 mg/l in Freeland. In general, levels of potassium were higher in the peat-free mixes in comparison to Levington M2, with the exception of Grodan and Bulrush.

Nitrate -N (NO_3) and **Ammonical -N (NH_4)** were analysed separately. The media types Wessex, Grodan, Shamrock and Freeland had very low initial levels of Ammonical-Nitrogen.

SHL and Petersfield mixes had much higher ammonical -N levels, 70 mg/l and 78 mg/l respectively. The other mixes had levels comparable to the control, Levington M2 (47 mg/l). Nitrate -N also varied. Levels were particularly low in Grodan and Wessex mixes, 15 mg/l and 1 mg/l respectively, whilst Shamrock had the highest recorded level at 253 mg/l.

Magnesium levels were lower in the mixes Grodan, Wessex, SHL, Petersfield and Freeland in comparison to the control, 83 mg/l, whilst levels of magnesium were considerably higher in Bulrush.

Calcium levels were lower in Wessex and SHL mixes at 9 mg/l and 12 mg/l respectively, whilst levels in Bulrush, Melcourt and Shamrock (385 mg/l, 252 mg/l and 241 mg/l respectively) were considerably higher than the control, 80 mg/l.

Conductivities were higher in all peat-free mixes in comparison to the control, 352.0, with the exception of Grodan and Wessex which were lower.

Samples of the growing media were taken at first records (mid-crop) for each species from each of the treatments, including the control. Full results of these analyses are presented in Appendix VI, Tables 12-28 (even nos.) on pages 57 to 65.

A summary of the analysis results (averaged across species) is presented in Table 2.

Table 2: Summary of media analysis results at mid-crop (across species)

	pH	P	K	Mg	Ca	Cond.^{ivity}	NO_3-N	NH_4-N
Control	5.8	60	79	71	80	247	67	10
Grodan	8.0	23	83	20	96	147	57	2
Wessex	-	-	-	-	-	-	-	-
SHL	6.6	43	281	7	14	267	30	11
Roffey	5.7	41	152	42	58	260	100	1
Bulrush	7.1	7	54	142	252	387	98	10
Melcourt	5.8	92	393	49	206	470	134	14
Shamrock	5.9	61	151	32	128	299	129	0.5
Petersfield	6.3	33	199	17	40	255	53	30
Freeland	7.7	25	520	13	75	392	26	1

pH levels were much higher in the media types Grodan, Bulrush and Freeland, whilst other growing media were at a more suitable pH level and comparable to the control, Levington M2.

Levels of **phosphorous** were lower in Bulrush (7 mg/l) whilst levels in Shamrock, Melcourt and also in the control were at much higher levels, 61 mg/l, 92 mg/l and 60 mg/l respectively.

Potassium levels varied widely. In Bulrush levels of K were below those in Levington M2. All other media types had potassium levels much higher than the control, with the highest levels recorded in Melcourt and Freeland at 393 mg/l and 520 mg/l respectively.

Nitrogen levels were depleted for both nitrate (NO_3) and ammonical (NH_4) forms of nitrogen. Levels of **ammonical -N** were all quite low with the exception of Petersfield which had a higher level at 30 mg/l.

Nitrate -N levels were higher in Roffey, Bulrush, Shamrock and Melcourt media with levels above that of the control, Levington M2. Levels of nitrate -N were lower in SHL and Freeland mixes in comparison to the control (67 mg/l).

Levels of **magnesium** were much lower in SHL, Petersfield and Freeland in comparison to the control (71 mg/l). Bulrush had considerably greater levels of magnesium, 142 mg/l.

Calcium levels varied widely between treatments. Levels in SHL, 14 mg/l, were much lower than those in Levington M2, 80 mg/l, whilst much higher levels were recorded in the Bulrush and Melcourt mixes, 252 mg/l and 206 mg/l respectively.

Conductivity levels were lowest in Grodan (147.0), whilst Bulrush, Melcourt and Freeland mixes recorded higher levels at 387, 470 and 392 respectively. Other media types had similar conductivity levels to the control, 247.

3.1.8 Leaf Tissue Analysis

Leaf tissue samples were analysed at first records (mid-crop) from the species *Begonia*, *Salvia*, *Impatiens* and Marigold. Full results of these analyses are given in Appendix VI, Tables 13-29 (odd nos.) on pages 57 to 63. A summary of the results is given over the page in Table 3.

Table 3: Summary of leaf tissue analysis results at mid-crop (across species*)

	%N	%P	%K	%Ca	%Mg	mg/kg Mn
Control	4.06	0.80	4.19	1.67	1.20	185.4
Grodan	4.25	0.67	4.01	2.52	0.80	124.9
Wessex	3.42	0.71	3.92	1.21	0.76	81.3
SHL	4.54	0.93	5.15	0.84	0.71	166.0
Roffey	4.22	0.67	4.29	1.53	1.22	220.5
Bulrush	3.93	0.47	2.97	2.17	1.32	393.6
Melcourt	4.02	0.66	5.48	1.90	0.74	636.2
Shamrock	3.90	0.69	4.13	2.48	0.77	963.2
Petersfield	3.95	0.83	4.18	1.63	0.59	278.0
Freeland	3.93	0.52	5.90	1.36	0.56	107.7

(* *Begonia*, *Salvia*, *Impatiens* and Marigold only)

As a guideline for the expected range of elements see Appendix X on page 84. Levels of percentage nitrogen were lowest in Wessex, and below that of the control. All other media types produced plants with a nitrogen content near to that of the control, Levington M2, at 4.06%.

All levels of phosphate were within the normal expected range and none were deficient. Levels of potassium varied between treatments. Bulrush produced plants with a low potassium percentage whilst SHL, Melcourt and Freeland had levels greater than 5%, at the higher end of the range.

Levels of calcium also varied, as did magnesium and manganese levels. The majority of levels were within the required range although levels of manganese were much higher in both Melcourt and Shamrock treatments, above the normal range.

3.2 Marketing Records

Summaries of results for each species are given in Appendix VII, Tables 30-35, pages 66 to 68. Figures in the tables which are in italics are the results where plants were watered independently of the control.

3.2.1 Geranium

Summaries of results are presented in Table 30, Appendix VII, page 66.

Plant Height: With the exception of plants grown in Melcourt and Freeland, all plants were of similar height to plants grown in Levington M2, 11.4cm, and there were no significant differences in height between treatments.

Where plants in each media type received watering on an individual basis, plant height was increased slightly. Plants grown in Freeland remained more compact, 9.9cm.

Rooting Score: Similarly as with plant height, there were no significant differences in rooting between treatments. Plants grown in Roffey had the highest rooting score, 3.0.

In the majority rooting was increased with the use of individual watering practices.

Plant Quality: Plants grown in Melcourt were of lower quality were the watering was standard across treatments. Where individual watering regimes were imposed there were no obvious differences in plant quality, all plants being of good quality at marketing.

Foliage Colour: Plants grown in Roffey and Petersfield had the darkest foliage with a score of 3.0 for each. Plants grown in Shamrock were very similar with a score of 2.7, whilst plants grown in peat, Levington M2, had a score of 2.0, the same as for plants grown in the other peat-free substrates, (with the exception of Melcourt which was visibly paler).

Fresh Weight: The greatest fresh weight was recorded for plants grown in Grodan which weighed 189.6g compared to plants grown in peat, Levington M2, which weighed 177.7g. Plants with reduced fresh weight were Freeland, Shamrock and particularly Melcourt.

Percentage Dry Matter: The highest level of dry matter was recorded for plants grown in Bulrush and Melcourt at 10.7% and 10.3% respectively. Plants grown in Levington M2, had a level of 8.9%.

3.2.2 *Salvia*

Summaries of results are presented in Table 31, Appendix VII, page 66.

Plant Height: Final measurements at marketing recorded a height of 33.7cm for plants grown in Levington M2. The majority of plants in each media were similar in height, although plants grown in Grodan and Roffey were considerably taller, 40.2cm and 38.5cm respectively.

Rooting Score: Rooting was obviously poorer for plants grown in Freeland. Better rooting was recorded for plants grown in Grodan and SHL, comparable to plants grown in peat, with a score of 3.0.

Rooting was increased for each treatment where individual watering practices were adopted.

Plant Quality: Plant quality was reduced where plants were grown in Bulrush, Melcourt and Freeland mixes primarily as a result of a reduction in overall plant size, but also in the case of Freeland due to paler foliage colour. The use of individual watering regimes generally increased the final quality of plants in each media type.

Foliage Colour: With the exception of plants grown in Freeland, all plants had good colour. Plants grown in Grodan, SHL, Roffey and Petersfield mixes had the darkest foliage and were comparable to plants grown in Levington M2.

The use of individual watering regimes generally increased the foliage colour of plants in each media type.

Fresh Weight: The greatest fresh weight was recorded for plants grown in Roffey, 326g. Plants grown in Levington M2 weighed 250g. Plants grown in Melcourt and Freeland were considerably smaller in size and hence had smaller fresh weights, 220g and 178g respectively.

Percentage Dry Matter: The highest level of dry matter was recorded for plants grown in Freeland at 10.3%. Plants grown in Levington M2 had a level of 8.7%.

3.2.3 Marigold

Summaries of results are presented in Table 32, Appendix VII, page 67.

Plant Height: Final measurements at marketing recorded a height of 13cm for plants grown in Levington M2. The majority of plants in each peat-free media were similar in height. The exceptions were plants grown in Melcourt and Shamrock which were visibly smaller at 10.7cm.

Where plants in each media type received watering on an individual basis, plant height was generally increased slightly.

Rooting Score: There were no large differences in rooting recorded at marketing between each treatment. Plants grown in Melcourt had a slightly reduced rooting score.

Rooting was not obviously different with the application of individual watering practices.

Plant Quality: With the exception of plants grown in Freeland and Wessex mixes, plants were of good quality and comparable to those plants grown in Levington M2. Plants grown in Wessex were obviously paler whilst plants grown in Freeland were smaller. The use of individual watering regimes did not affect the final plant quality scores.

Foliage Colour: The darkest foliage colour was recorded for plants grown in Shamrock and Roffey mixes. With the exception of plants grown in Wessex, all other plants grown in peat-free media were comparable to plants grown in Levington M2. Plants grown in Wessex appeared much paler in comparison to the control.

Fresh Weight: The greatest fresh weight was recorded for plants grown in SHL, 154.2g. Plants grown in Levington M2 weighed 117.7g. Plants grown in Grodan, Wessex, Melcourt, Shamrock and Freeland were considerably smaller in size and hence had smaller fresh weights.

Percentage Dry Matter: The highest level of percentage dry matter was recorded for plants grown in Shamrock at 11%. Plants grown in Levington M2 had a level of 8.7%.

3.2.4 *Petunia*

Summaries of results are presented in Table 33, Appendix VII, page 67 and colour plates 11-13, Appendix VIII, pages 69-71.

Plant Height: Final measurements at marketing recorded a height of 23.2cm for plants grown in Levington M2. Plant height in each of the peat-free medias varied greatly. The tallest plants were recorded in Petersfield with a height of 25.5cm, and plants appeared 'leggy' in the box.

Plants which compared closely with those grown in Levington M2 were those grown in Roffey. The smallest plants were grown in Freeland, with a final height of 7.9cm.

Where plants in each media type received watering on an individual basis, plant height was successfully manipulated to result in final plant height very similar to that achieved of plants grown in Levington M2.

Rooting Score: Rooting recorded at marketing was poorer in SHL and Bulrush in comparison to plants grown in Levington M2. Plants grown in Melcourt had a slightly reduced rooting score, whilst plants in each of the other media types had better rooting than the control, with the best rooting in Petersfield with a score of 2.8.

Rooting was not obviously different with the application of individual watering practices.

Plant Quality: Plant quality varied between treatments. The best quality plants were deemed to be those grown in Grodan, SHL and Shamrock which were of a good size and habit. Plants grown in Petersfield became too vigorous and 'leggy', whilst plants in Bulrush and Melcourt remained more compact.

Foliage Colour: With the exception of plants grown in Bulrush which were paler, all other plants grown in peat-free media were comparable to plants grown in Levington M2, if not with better foliage colour. The use of independent watering/feeding practices for each media type did not greatly affect foliage colour.

Fresh Weight: The greatest fresh weight was recorded for plants grown in Petersfield, 385.0g. Plants grown in Levington M2 weighed 355.0g. Plants grown in Grodan, SHL, Shamrock and Freeland were considerably smaller in size and hence with smaller fresh weights.

Percentage Dry Matter: The highest level of dry matter was recorded for plants grown in Grodan and Shamrock at 9.1%. Plants grown in Levington M2, had a level of 6.7%. Plants grown in Melcourt and Freeland had percentage dry matters of 5.1% and 5.8% respectively.

3.2.5 *Begonia*

Summaries of results are presented in Table 34, Appendix VIII, page 68.

Plant Height: Final measurements at marketing recorded a height of 17.9cm for plants grown in Petersfield in comparison to 7.0cm for plants grown in Levington M2. Plants grown in Petersfield were by far the most vigorous. Plant height in each of the other peat-free medias did not vary greatly from that of plants grown in Levington M2, with the exception of plants grown in either the Bulrush or Melcourt mixes which were 5.1cm in height and appeared much smaller.

Where plants in each media type received watering on an individual basis, plant height was increased in all growing media types with the exception of Freeland in which plant height was reduced. Plants grown in Grodan and Roffey mixes responded the most with final plant heights of 17.0cm and 12.0cm respectively.

Rooting Score: Rooting was good in all media types with the exception of both Bulrush and Melcourt mixes. Rooting improved in Bulrush where the media was watered independently of the control, but no improvement in rooting was recorded for plants grown in Melcourt. The best rooting was recorded for plants grown in Grodan, Petersfield and Shamrock, although rooting in Shamrock was poorer when grown under an independent watering regime to the control.

Plant Quality: With the exception of plants grown in Freeland and to a lesser extent Melcourt, plants were of good quality and comparable to those plants grown in Levington M2. Plants grown in Freeland and Melcourt were smaller and not as uniform.

Foliage Colour: The darkest foliage colour was recorded for plants grown in Melcourt, with a score of 2.6 (max. 3) and compared favourably to plants grown in Levington M2 which recorded a score of 2.8. Foliage colour improved for plants grown in Bulrush and SHL where plants were treated independently of the control for watering. There was no improvement in colour for plants in any of the other mixes and in most cases the foliage colour was poorer.

Fresh Weight: The greatest fresh weight was recorded for plants grown in Petersfield and reflected their more vigorous habit. All other treatments produced plants of comparable or considerably larger fresh weights than plants grown in Levington M2.

Percentage Dry Matter: The highest level of dry matter was for plants grown in Bulrush and Melcourt, 4.8% and 4.5% respectively, and compares with plants grown in Levington M2 which had a percentage dry matter at 4.3%. Plants grown in other treatments had a lower percentage dry matter. Plants grown in Petersfield and Grodan had the lowest with 3.2% and 3.1% respectively.

3.2.6 *Impatiens*

Summaries of results are presented in Table 35, Appendix VII, page 68 and in colour plates 14-16, Appendix VIII, pages 72-74.

Plant Height: Plant height varied quite considerably at marketing and reflected the vigour and habit of plants grown in each of the mixes. The tallest plants were produced in Grodan, SHL and Petersfield mixes with heights of 18.6cm, 17.6cm and 18.1cm, compared to plants grown in Levington M2 which reached 10.7cm and were of better proportion in size. Plants grown in Shamrock and Bulrush were more comparable to plants grown in Levington M2 with heights of 10.3cm and 9.9cm respectively.

Rooting Score: With the exception of plants grown in Melcourt and Freeland, rooting was better in other media types in comparison to plants grown in Levington M2 which had a score of 1.8. Rooting was increased in each treatment, with the exception of Melcourt, when plants were grown independently of the control in terms of watering.

Plant Quality: With the exception of plants grown in Melcourt and Freeland, plant quality was comparable to plants grown in Levington M2 and all were of good quality. Plant quality was lower for Melcourt and Freeland due to smaller plant size/habit and less uniformity in growth between plants.

Foliage Colour: The darkest foliage colour was recorded for plants grown in SHL, Bulrush and Petersfield mixes. With the exception of plants grown in Melcourt and Freeland mixes which were paler, all other plants grown in peat-free media were comparable to plants grown in Levington M2.

Fresh Weight: The greatest fresh weight was recorded for plants grown in Petersfield, 278.0g. Plants grown in Levington M2 weighed 186.0g. Plants grown in Wessex, Melcourt and Freeland were considerably smaller in size and hence with smaller fresh weights.

Percentage Dry Matter: The highest level of dry matter was recorded for plants grown in Melcourt at 7.3%. Plants grown in Levington M2 had a level of 6.0%. The lowest level of percentage dry matter was recorded for plants grown in SHL mix, 4.2%

3.2.7 Growing Media Analysis

Samples from each media type x species were taken at maturity (marketing). Full results are presented in tables 36 to 52 (even nos.) in Appendix IX, pages 75 to 83.

Table 4 is a summary of the media analysis results averaged across species.

Table 4: Summary of media analysis results at marketing (across species)

	pH	P	K	Mg	Ca	Cond.^{ivity}	NO_3-N	NH_4-N
Control	5.8	61	82	79	81	237	71	1
Grodan	7.9	8	65	9	53	104	20	0
Wessex*	6.8	16	152	1	9	148	18	1
SHL	6.4	35	216	12	17	218	28	0.5
Roffey	5.8	47	143	46	56	251	96	1
Bulrush	7.2	6	52	123	195	375	75	1
Melcourt	6.0	69	323	42	166	396	111	13
Shamrock	6.1	69	165	29	113	230	106	0
Petersfield	6.0	27	164	22	56	200	53	1
Freeland	7.9	26	415	12	63	314	30	0

* for *Salvia*, *Impatiens* and Marigold only.

pH levels were higher in Grodan, Wessex, Bulrush and Freeland mixes in comparison to the control, Levington M2.

Phosphorous levels varied quite widely with levels lower in Grodan, Wessex and Bulrush. Levels of phosphorous in SHL, Petersfield and Freeland were lower than those in the control but satisfactory. All other media types had levels comparable to the control.

Potassium levels also varied widely. The highest levels were in Melcourt and Freeland mixes, 323 mg/l and 415 mg/l respectively, whilst lower levels were recorded in Bulrush and Grodan at 52 mg/l and 65 mg/l respectively.

Ammonical-nitrogen levels were all low with the exception of Melcourt which had a level of 13 mg/l. Levels of **nitrate-nitrogen** were highest in Melcourt, Shamrock and Roffey mixes, above that of the control (71 mg/l). Levels of nitrate-nitrogen were lower in Grodan, Wessex and Freeland mixes, 20 mg/l, 18 mg/l and 30 mg/l respectively.

Levels of **magnesium** were considerably higher in Bulrush at 123 mg/l, whilst hardly any magnesium was present in Wessex. Generally, the levels of magnesium were lower in the peat-free media mixes in comparison to the control.

Levels of **calcium** were higher in comparison to the levels of magnesium. Bulrush and Melcourt recorded the highest levels at 195 mg/l and 166 mg/l respectively. The lowest levels were in Wessex and SHL mixes at 9 mg/l and 17 mg/l respectively.

Conductivity levels were lower in the Grodan and Wessex mixes, but levels in the other peat-free media were not too dissimilar to the control. Bulrush and Melcourt had the highest conductivity levels.

3.2.8 Leaf Tissue Analysis

Leaf tissue samples were taken at maturity (marketing) from each species x media treatment. Full results of these analyses are presented in Tables 37 to 53, Appendix IX, pages 75 to 83.

A summary of the analysis results are given in Table 5 below.

Table 5: Summary of leaf tissue analysis results at marketing (across species*)

	%N	%P	%K	%Ca	%Mg	mg/kg Mn
Control	4.18	0.92	4.98	1.58	1.05	185.7
Grodan	4.02	0.68	4.26	2.18	0.59	96.3
Wessex*	3.67	0.82	6.12	1.27	0.53	66.4
SHL	4.15	0.87	5.70	0.83	0.56	189.7
Roffey	4.25	0.80	4.77	1.50	1.01	207.3
Bulrush	3.91	0.57	4.09	2.02	1.07	457.5
Melcourt	4.09	0.73	5.54	1.85	0.55	644.0
Shamrock	3.73	0.75	4.50	2.16	0.62	995.4
Petersfield	4.21	0.80	5.18	1.56	0.48	297.4
Freeland	3.89	0.61	6.67	1.25	0.46	116.3

(* across *Salvia*, *Impatiens* and Marigold only)

Levels of **nitrogen** were lowest in Wessex at 3.67%, but generally levels of nitrogen were within the guidelines (see Appendix X, page 84). Similarly the levels of **phosphorous** were all within the range regarded as suitable for healthy plants, and there were no deficiency levels recorded.

Levels of **potassium** varied more widely. The highest levels were found in Wessex and Freeland, 6.12% and 6.67% respectively, above those provided in the guidelines. In general, the other media types were comparable to the control, Levington M2, 4.98%, although Bulrush had lower levels at 4.09%.

Calcium levels were all within the guideline values given in Appendix X, although calcium levels were considerably lower in SHL at 0.83%.

Magnesium levels were generally lower than the control, with the exception of Roffey and Bulrush which were comparable at 1.01% and 1.07% (control = 1.05%).

Manganese levels varied greatly with highest levels in Bulrush, Melcourt and particularly Shamrock (457.5 mg/kg, 644.0 mg/kg and 995.4 mg/kg respectively), considerably higher than the control, 185.7 mg/kg. The lowest level was recorded in Wessex.

4. DISCUSSION

The aim of this trial was to evaluate a range of peat-free or reduced peat growing media for bedding plants in direct comparison to the use of a peat-based growing medium, Levington M2.

The commercial bedding plant grower may be faced today with a customer who requires plants to be grown in a peat-free media. Many of the large multiple retailers are continuing to assess their marketing policy and the potential for plants to be supplied in non-peat growing media, and often without being treated with certain pesticides. In addition, there has been an increase in the range of peat-free media being targeted towards the commercial bedding plant grower. The manufacturing companies, many of whom are reliant on peat for the bulk of their trade, recognise there is a demand, if not an immediate need for peat-free growing media. Thus, the commercial grower has recently been faced with a number of new products.

This trial was based on the expectancy that growers would initially grow plants as they had always done so in peat. It would also not be unexpected to find larger growers meeting the demands of the larger multiples to grow in peat-free materials by growing plants in peat-free and peat-based media alongside each other in the same glasshouse environment and under identical watering and feeding regimes. Therefore in the initial stages of the trial this practice was adopted. Plants grown in the peat-free treatments were treated the same as for plants grown in the peat-based media, Levington M2. This approach would clearly demonstrate each media's response to such a regime and identify any changes in cultural practice which would need to be considered by a grower.

In total nine peat-free media were trialled directly in comparison to Levington M2, and six plant species were grown; *Impatiens*, Marigold, *Salvia*, *Petunia*, Geranium and *Begonia*. Plant growth assessments were taken at mid-crop stage (3-5 weeks) and also at maturity. A series of growing media and leaf tissue samples were also taken for a comparative view of each media type.

The results in plant growth even at the first records (mid-crop) showed clearly the wide variation in growth from the different media types. Plant growth was more vigorous in coir-based media types, and in Petersfield growth appeared 'soft'. At this stage it appeared that the irrigation frequency and the amount applied had the greatest influence on plant growth. There were no elemental deficiencies or toxicities, although Wessex appeared to lack sufficient nitrogen in its base. It is important to note that the results at this stage, mid-crop, are purely based on the watering regime and base fertilizer in each media type. There had been no supplementary liquid feeding until now.

The trends in plant growth recorded at first records continued, and were again apparent at marketing. In general the coir-based media produced plants more comparable to those grown in Levington M2, although at this stage there were more subtle differences between media types. Petersfield produced the most vigorous plants in all species, but their final quality was reduced as a consequence, with the growth appearing too 'soft' and 'leggy'. Its nitrogen content was high in its early stages, particularly its ammonical -N level, which would have promoted plant vigour and 'soft' growth.

The results highlighted the differences which exist between bark-based and coir-based mixes in comparison to peat. The majority of the media used in this trial fell into either of these two groups. The exceptions were obviously Grodan (rockwool product) and Freeland which was based on composted green waste material.

The bark-based materials tended to produce plants which were 'harder' and more compact. Under the watering regime employed in the first stages of the trial, plant establishment was much slower as a consequence, and rooting scores in these media types were lower. There were differences in nutrition between each media type and in general the bark-based mixes tended to have a higher base feed and conductivity.

Throughout the trial, plants grown in bark-based media types remained smaller, but at marketing their quality was often deemed to be better as the plants were more compact and unlike other treatments had not produced over-vigorous 'soft' plants. This is an important consideration for plant handling in marketing and 'shelf-life'. Plants responded favourably when after first records watering was based on each media type independently.

Care needs to be taken with both bark and coir media types. Typically it was found with bark-based media that the surface of the media dried out acting as a mulch preventing water loss through evaporation from the media. This could possibly be detrimental whereby the immediate humidity around a plant is lowered, causing a reduction in plant growth. In contrast, this could be advantageous in the possible prevention of disease, particularly *Botrytis*. However, this was not examined within the context of this trial. It also became apparent that although the bulk of the media of bark-based materials remained moist, this water did not appear to be freely available to the plant i.e. material had a greater ability to hold onto moisture rather than for the root system to take advantage of this water source. Therefore, plants grown in bark needed to be watered more often and thoroughly to ensure the full depth of the media was watered sufficiently. The nature of bark-based materials means that they are relatively easy to rewet.

The coir-based medias responded very differently to the bark-based medias and, with the exception of the mixes Wessex and Petersfield, were more comparable to plants grown in Levington M2. Plants in Roffey and SHL mixes were of good quality and similar in growth and size to plants grown in Levington M2. Like the bark types, the coir mixes also varied in their nutrition. Wessex was lower in nitrogen at the start of the trial (pricking off). Earlier feeding may be necessary for some of the media types, and more careful attention should be paid to their nutrient status during production.

In terms of weight, the coir-based products were comparable to peat (although immediately after irrigation box weight was much heavier). In contrast, the bark-based materials were naturally heavier, particularly Bulrush. The nature of the materials being coarser also meant the product was not as easy to handle. In machine handling the coarser grade abrasive material may be better able to withstand compression/breakdown of particle size, but consequently wear and tear on machinery could be higher.

Rockwool was obviously the 'odd' material within those on trial. It was treated differently to Levington M2 from pricking off as the mix used had no base feed and it was therefore fed subsequently with liquid feed at every watering. The material was very light which can be an advantage in manual handling of boxes/marketing. Box filling was slower and the material would not immediately suit automatic box fillers. However, its open structure proved very favourable for early root development and establishment, and plants were successfully grown in rockwool. The standard liquid feeding regime employed would need to be addressed as foliage colour was paler on all species grown. Also, the material has little buffering ability and its initial pH is also very high.

The product submitted by Freeland Technologies could be said to be the only 'true green' material, based on composted green waste material. Its performance reflected closely that experience with the bark-based media types, and plant growth was more compact. No nutrient deficiencies were found, although paler foliage in *Petunia* and *Salvia* indicated that earlier liquid feeding may be necessary or for an increase to be made in the base feed (nitrogen).

In summary, **all** media types produced plants of acceptable quality at sale. The range of results demonstrates the differences in each of the media types available and their effect on plant growth. It is important for growers to be aware that a peat-free media cannot be treated just like a peat-based growing media. Changes in watering and feeding practices would often be necessary to fully optimise the performance of each of these media types/products. The manufacturing companies are becoming aware of the importance of pre- and after-sales service, and close liaison with the growing media supplier would be important for the grower to understand the performance and requirements of each growing media.

5. CONCLUSIONS

- Peat-free media are now available which can be successfully used in the commercial production of bedding plants.

- Each media type would require changes to traditional cultural practices to optimise their performance for plant growth. This may be either as altered watering frequency and/or change in supplementary liquid feeding regimes.

- Costs of peat-free growing media are dropping and are becoming more comparable to peat-based growing media.

- Some peat-free growing media can have beneficial effects in plant production: coir appeared to facilitate earlier root vigour and establishment whilst the bark-based media appeared to have a greater buffer capacity between wet and dry waterings.

- Growth of plants in different media types can influence shelf-life and subsequently quality of the plant.

6. COST - BENEFIT FOR THE GROWER

The use of alternative peat-free growing media has been limited due to a number of factors. Until recently its reliability in supply and use could not be guaranteed from one batch to the next. The market for peat-free grown plants also appeared more limited than originally anticipated, but probably the biggest influential factor was the cost of peat-free materials in comparison to peat-based growing media. This probably still remains a large contributory factor as to whether peat-free susbstrates will establish a reliable market.

However, these *costs* need to be considered against the potential *benefits* which may exist for the grower. Costs do not only include the supply of the products, but the grower should also examine the changes which may be necessary in his/her production practices so that the performance of a peat-free growing media is maximised. It has been identified from this trial that dependent on the material used, changes should be employed in both watering and feeding practices. A direct cost cannot be given within this scope of this project as every nursery has a different operating system and changes to a production system and the costs which would be incurred would vary from one nursery to another. In addition to the changes likely in watering and feeding there are a number of other factors. The physical characteristics of a product must also be evaluated. The abrasive and coarser structure of some of the bark-based materials may cause additional wear to machinery, whilst in the case of some materials, their weight will be important both in terms of manual handling, but also during production and at marketing/sale. Boxes of pack or pot bedding which are much heavier than a normal peat-based medium may not attract consumers who may be reluctant to purchase, either 'unsure' of the new media type or simply not willing to carry a box/plant which is heavy! Another factor at marketing which is of importance to all growers, but maybe more so for growers transporting material, is plant quality and specifically the height and habit of the plants. It was seen within this trail that plants grown in many of the bark-based materials remained more compact in their habit and of 'harder' appearance, with good quality. It would be possible to accommodate a higher number of plants onto danish trolleys if plants were more compact, facilitating more shelves per unit. In contrast, plant growth which is too 'soft' and 'leggy', found in some of the coir-based materials not only restricts the number of plants which can be fitted onto a danish trolley, but their durability in handling and shelf-life may be poorer. This can be partly overcome by adopting different cultural practices to manage plant growth more effectively.

These outline some of the *costs* which may be incurred with a change in growing media, and are summarised as follows:

- physical properties which may be more abrasive to machinery increasing wear and tear, or flowability reduced-slowing potting, etc.
- added weight in terms of manual handling and at point of sale.
- additional cost of materials.
- changes in watering/feeding regimes which may necessitate additional equipment and/or time.

The main *benefit* from the use and sale of peat-free grown plants is a perceived demand and higher price return, based on the environmentally 'friendly' image. However, it should not be expected to receive a premium price for plants produced in peat-free materials, but this could be an economical benefit if it could be achieved through active marketing and promotion. To date however, it appears that consumers often base their purchase on impulse buys, or often price and where peat-free grown plants are at a premium price. Peat-grown plants are often the first to be purchased instead. Therefore, although an increased return should not be ignored, it cannot always be expected. Thus possibly the main benefit from growing in peat-free media is removed. However, there are additional *benefits* which should be considered. Firstly, the price of many peat-free materials has been dropping in the past couple of years to a level which is now directly comparable to that of peat (Table A overleaf).

Table A **Outline costs for some peat-free substrates in comparison to a peat-based growing medium**

Cost* £/m^3	Supplier/Product
35.70	Bulrush Sunrise 12
45.00[1]	Wessex Coccompost
28-32.00	Roffey Coir Potting Mix
15.50[2]	Melcourt Sylvafibre
36.50	Petersfield Peat Free Supreme
32.00	Freeland Technologies
46.00[3]	**Levington, M2**

* based on supply in bulk (50/60m^3)
1 based on supply as 80 litre bags on pallets
2 cost of Sylvafibre only which will need to be mixed with another base material
3 based on supply as 75 litre bags on pallets

This would make peat-free substrates more appealing, in that the immediate cost of purchase would be the same or even lower than that of a comparable peat-based substrate. There may be potential to increase plant quality through the use of peat-free media types, and reduce inputs. The higher water holding capacity of coir could be a potential 'benefit' if this reduced water usage, and earlier root vigour and plant establishment have been demonstrated in these media types. Alternatively bark-based materials have been previously associated with a reduction in root diseases. Thus, the use of peat-free based growing media may actually improve plant quality and growth when used effectively.

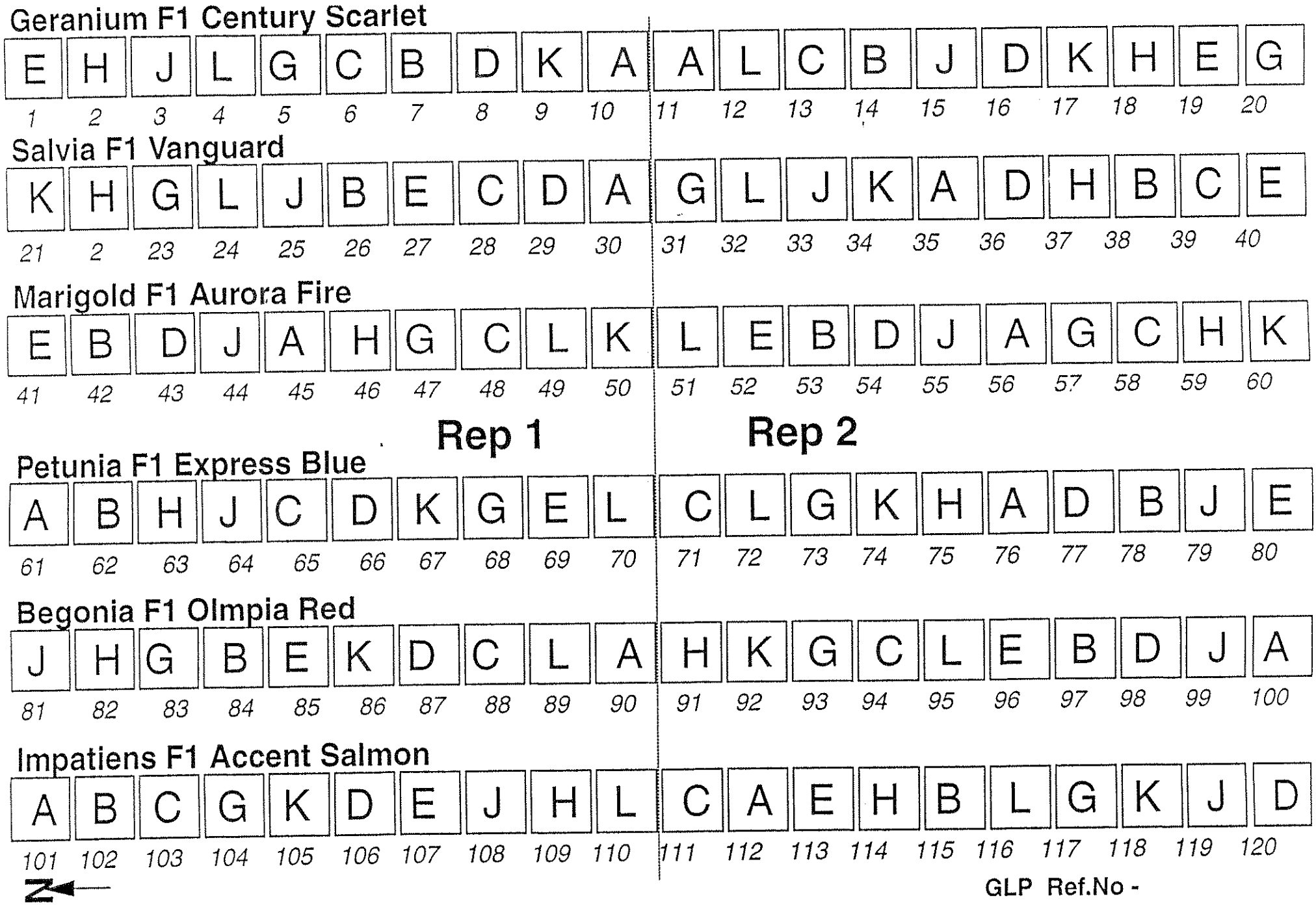
The potential benefits are summarised below:

- higher market returns for peat-free grown plants.
- improvement in plant growth and quality.
- costs of materials are dropping and are more favourable to that of peat.

As each commercial nursery can have both a different production system and serve a different market, each grower must weigh up the pros and cons for the use of alternative growing medias. In the future, the long term availability of coir and its 'greenness' may be examined in more detail, whilst it is likely that within the UK more research, with industrial backing, will evaluate the recycling of waste materials for use in plant production.

APPENDICES

COMMERCIAL - IN CONFIDENCE



APPENDIX II

Crop Diary

	*Impatiens**	*Salvia***	Marigold	*Petunia*	Geranium***	*Begonia*
Sown	2 Feb (*16 Mar*)	2 Feb (*15 Mar*)	21 Mar	2 Feb	1 Feb	23 Jan
Emergence	10 Feb (*23 Mar*)	9 Feb (*21 Mar*)	23 Mar	9 Feb	4 Feb	7 Feb
Cotyledons expanded	15 Feb (*26 Mar*)	13 Feb (*23 Mar*)	-	-	9 Feb	-
Start feeding plugs	23 Feb (*1 Apr*)	23 Feb (*29 Mar*)	30 Mar	1 Mar	23 Feb	1 Mar
Prick off	8 Mar (*14 Apr*)	7 Mar (*11 Apr*)	12 Apr	9 Mar	9 Mar	23 Mar
Start feeding plants	6 Apr (*1 May*)	6 Apr (*1 May*)	1 May	6 Apr	6 Apr	21 Apr

* (*italics*) show dates for second replicate.

** *Iprodine* as Rovral applied on 27 March (Replicate 1), 0.5 g/l.

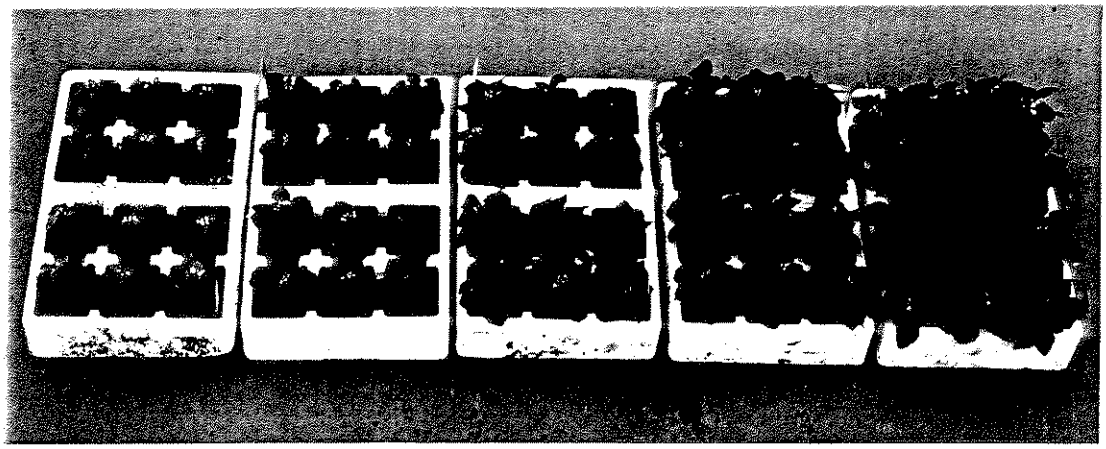
*** Cycocel applied at 1 ml/l (46% ai) on 24 February, 14 March and 22 March.

Pest and disease control - a biological control programme was used with routine introductions of *Amblyseius cucumeris* for Thrip, *Aphidius matricaria, Aphidoletes aphidomyza* for Aphid, *Encarsia formosa* for Whitefly and *Phyoseilus persimilis* for Red Spider Mite.

APPENDIX III

Plate 1 *Impatiens* : Photographs of Assessment Scores at First Records

% Cover Score

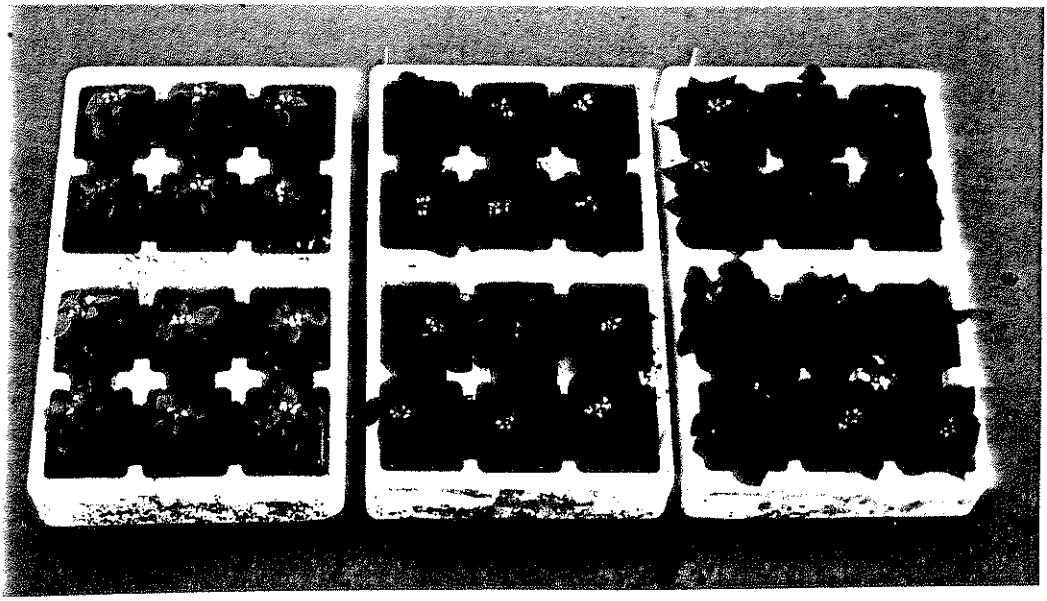


1 2 3 4 5

Rooting Score

1 2 3

Foliage Colour Score



1 2 3

APPENDIX IV

Plant Growth Records - First Records

Table 6 Geranium (recorded at 6 weeks post pricking-off)

Product	Cover Score[1] (1-5)	Rooting Score[2] (1-3)	Plant Quality[3] (0-2)	Foliage Score[4] (1-3)	Fresh Weight (g)	% Dry matter
Grodan	3.96	1.62	2.00	2.17	61.0	16.3
Wessex	-	-	-	-	-	-
SHL	4.79	2.42	2.00	2.00	81.0	14.0
Roffey	4.71	2.42	2.00	2.42	73.0	15.3
Bulrush	2.21	1.00	1.54	2.00	36.0	17.0
Melcourt	2.79	1.17	1.62	2.12	44.0	16.0
Shamrock	3.08	1.58	2.00	2.50	48.0	15.2
Petersfield	4.79	2.08	2.00	3.00	76.0	14.4
Freeland	2.46	1.21	1.71	2.00	35.0	19.6
Levington	4.92	2.33	2.00	2.37	58.0	14.1
d.f. = 8						
SED = ±	*0.287*	*0.187*	*0.035*	*0.123*	-	-
LSD = ±	*0.661*	*0.430*	*0.082*	*0.284*	-	-

(1) Cover score 1-5, 1 = 0-20%, 2 = 21-40%, 3 = 41-60%, 4 = 61-80%, 5 = 81-100%.

(2) Rooting score 1-3, 1 = poorest, 3 = most vigorous.

(3) Plant quality 0-2, 0 = unmarketable/v. poor, 2 = best.

(4) Foliage score 1-3, 1 = palest, 3 = darkest.

APPENDIX IV

Plant Growth Records - First Records

Table 7 *Salvia* (recorded at 4 weeks post pricking-off)

Product	Plant Height[1] (cm)	Rooting Score[2] (1-3)	Plant Quality[3] (0-2)	Foliage Score[4] (1-3)	Fresh Weight (g)	% Dry matter
Grodan	9.1	2.79	2.00	2.00	49.5	14.2
Wessex	4.7	1.17	1.00	1.00	21.0	8.1
SHL	8.3	2.75	2.00	3.00	59.0	11.4
Roffey	8.4	2.12	2.00	2.79	56.0	12.3
Bulrush	6.1	1.92	1.83	2.87	26.0	14.9
Melcourt	6.2	1.33	1.29	2.79	26.0	12.9
Shamrock	8.2	1.79	1.83	2.83	35.0	13.1
Petersfield	7.6	2.71	2.00	3.00	51.0	11.7
Freeland	6.8	1.54	1.29	2.00	26.0	12.1
Levington	7.3	2.33	2.00	3.00	37.5	12.6
d.f. = 8						
SED = ±	*1.067*	*0.328*	*0.234*	*0.136*	-	-
LSD = ±	*2.459*	*0.757*	*0.539*	*0.315*	-	-

(1) Plant height, from base of plant to top of foliage canopy.

(2) Rooting score 1-3, 1 = poorest, 3 = most vigorous.

(3) Plant quality 0-2, 0 = unmarketable/v. poor, 2 = best.

(4) Foliage score 1-3, 1 = palest, 3 = darkest.

APPENDIX IV

Plant Growth Records - First Records

Table 8 Marigold (recorded at 3 weeks post pricking-off)

Product	Plant Height[1] (cm)	Rooting Score[2] (1-3)	Plant Quality[3] (0-2)	Foliage Score[4] (1-3)	Fresh Weight (g)	% Dry matter
Grodan	11.3	3.00	2.00	2.00	64.0	9.8
Wessex	7.6	1.83	1.00	1.00	24.0	12.1
SHL	10.8	2.75	2.00	2.50	99.0	8.1
Roffey	10.4	3.00	2.00	2.50	85.0	9.2
Bulrush	10.6	3.00	2.00	3.00	51.0	10.9
Melcourt	90.0	2.67	1.92	3.00	35.0	11.6
Shamrock	9.5	2.00	1.96	3.00	41.0	12.9
Petersfield	11.2	3.00	2.00	3.00	81.0	8.7
Freeland	9.1	2.92	1.00	1.50	30.0	12.5
Levington	10.8	3.00	2.00	3.00	75.0	9.2
d.f. = 8						
SED = ±	*4.889*	*0.084*	*0.040*	*0.342*	-	-
LSD = ±	*11.06*	*0.191*	*0.092*	*0.788*	-	-

(1) Plant height, from base of plant to top of foliage canopy.
(2) Rooting score 1-3, 1 = poorest, 3 = most vigorous.
(3) Plant quality 0-2, 0 = unmarketable/v. poor, 2 = best.
(4) Foliage score 1-3, 1 = palest, 3 = darkest.

APPENDIX IV

Plant Growth Records - First Records

Table 9 *Petunia* (recorded at 4 weeks post pricking-off)

Product	Cover Score[1] (1-5)	Rooting Score[2] (1-3)	Plant Quality[3] (0-2)	Foliage Score[4] (1-3)	Fresh Weight (g)	% Dry matter
Grodan	4.67	2.92	2.00	2.50	60.0	11.0
Wessex	-	-	-	-	-	-
SHL	5.00	2.67	1.50	3.00	146.0	7.0
Roffey	5.00	2.54	1.00	2.00	162.0	6.8
Bulrush	1.96	1.29	1.50	1.00	29.0	17.0
Melcourt	2.00	1.12	1.00	1.00	39.0	16.9
Shamrock	4.42	2.46	2.00	3.00	72.0	10.3
Petersfield	4.92	2.12	1.00	2.00	150.0	7.5
Freeland	1.46	1.67	1.50	2.00	36.0	16.5
Levington	4.79	2.04	1.00	1.50	75.0	10.0
d.f. = 8						
SED = ±	*0.418*	*0.213*	*0.425*	*0.312*	-	-
LSD = ±	*0.964*	*0.490*	*0.980*	*0.719*	-	-

(1) Cover score 1-5, 1 = 0-20%, 2 = 21-40%, 3 = 41-60%, 4 = 61-80%, 5 = 81-100%.

(2) Rooting score 1-3, 1 = poorest, 3 = most vigorous.

(3) Plant quality 0-2, 0 = unmarketable/v. poor, 2 = best.

(4) Foliage score 1-3, 1 = palest, 3 = darkest.

APPENDIX IV

Plant Growth Records - First Records

Table 10 *Begonia* (recorded at 4 weeks post pricking-off)

Product	Cover Score[1] (1-5)	Rooting Score[2] (1-3)	Plant Quality[3] (0-2)	Foliage Score[4] (1-3)	Fresh Weight (g)	% Dry matter
Grodan	3.54	1.08	2.00	2.67	78.0	4.5
Wessex	-	-	-	-	-	-
SHL	2.13	1.04	1.92	2.71	58.0	4.3
Roffey	3.13	1.46	2.00	2.71	58.0	4.6
Bulrush	1.71	1.00	1.75	2.12	22.0	5.0
Melcourt	1.83	1.00	1.67	1.92	39.0	5.2
Shamrock	2.38	1.00	1.83	2.29	65.0	4.9
Petersfield	4.33	1.67	2.00	3.00	111.0	4.1
Freeland	2.46	1.00	1.71	2.12	54.0	4.1
Levington	2.25	1.29	1.87	2.58	37.0	4.6
d.f. = 8						
SED = ±	*0.569*	*0.177*	*0.121*	*0.253*	-	-
LSD = ±	*1.310*	*0.408*	*0.278*	*0.584*	-	-

(1) Cover score 1-5, 1 = 0-20%, 2 = 21-40%, 3 = 41-60%, 4 = 61-80%, 5 = 81-100%.

(2) Rooting score 1-3, 1 = poorest, 3 = most vigorous.

(3) Plant quality 0-2, 0 = unmarketable/v. poor, 2 = best.

(4) Foliage score 1-3, 1 = palest, 3 = darkest.

APPENDIX IV

Plant Growth Records - First Records

Table 11 *Impatiens* (recorded at 4 weeks post pricking-off)

Product	Cover Score[1] (1-5)	Rooting Score[2] (1-3)	Plant Quality[3] (0-2)	Foliage Score[4] (1-3)	Fresh Weight (g)	% Dry matter
Grodan	4.00	2.75	2.00	2.00	71.0	5.9
Wessex	-	-	-	-	-	-
SHL	3.87	1.42	2.00	3.00	63.0	7.0
Roffey	3.83	1.71	2.00	3.00	47.5	7.1
Bulrush	1.79	1.75	2.00	3.00	51.0	7.5
Melcourt	1.29	1.00	2.00	3.00	25.0	7.0
Shamrock	3.38	1.62	2.00	3.00	52.5	7.8
Petersfield	3.96	1.87	2.00	3.00	71.0	7.0
Freeland	1.67	1.37	2.00	2.00	41.5	6.7
Levington	3.42	1.33	2.00	3.00	47.5	7.0
d.f. = 8						
SED = ±	*0.657*	*0.416*	-	-	-	-
LSD = ±	*1.52*	*0.959*	-	-	-	-

(1) Cover score 1-5, 1 = 0-20%, 2 = 21-40%, 3 = 41-60%, 4 = 61-80%, 5 = 81-100%.

(2) Rooting score 1-3, 1 = poorest, 3 = most vigorous.

(3) Plant quality 0-2, 0 = unmarketable/v. poor, 2 = best.

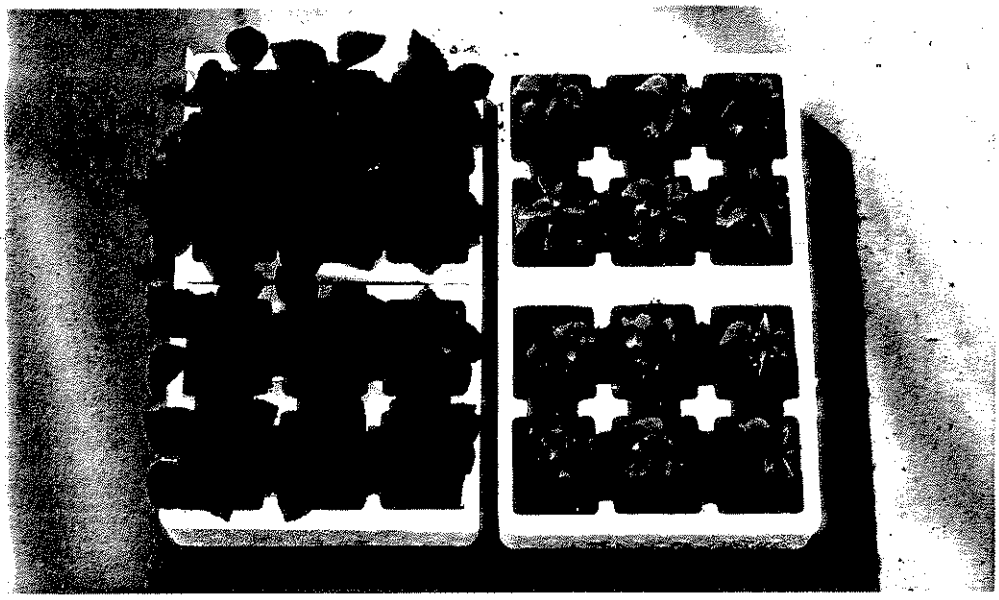
(4) Foliage score 1-3, 1 = palest, 3 = darkest.

COMMERCIAL IN CONFIDENCE

APPENDIX V

Plate 2 *Salvia* : Treatment Comparison at First Records
(control - Levington M2, on left)

Rockwool



Wessex

SHL

COMMERCIAL - IN CONFIDENCE

APPENDIX V

Plate 3 *Salvia* : Treatment Comparison at First Records
(control - Levington M2, on left)

Roffey

Bulrush

Melcourt

APPENDIX V

Plate 4 *Salvia* : Treatment Comparison at First Records
(control - Levington M2, on left)

Shamrock

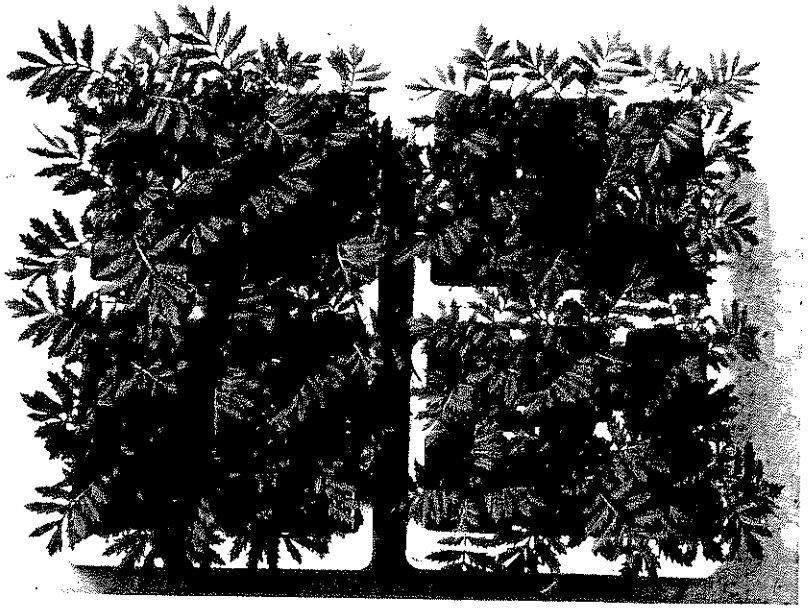
Petersfield

Freeland

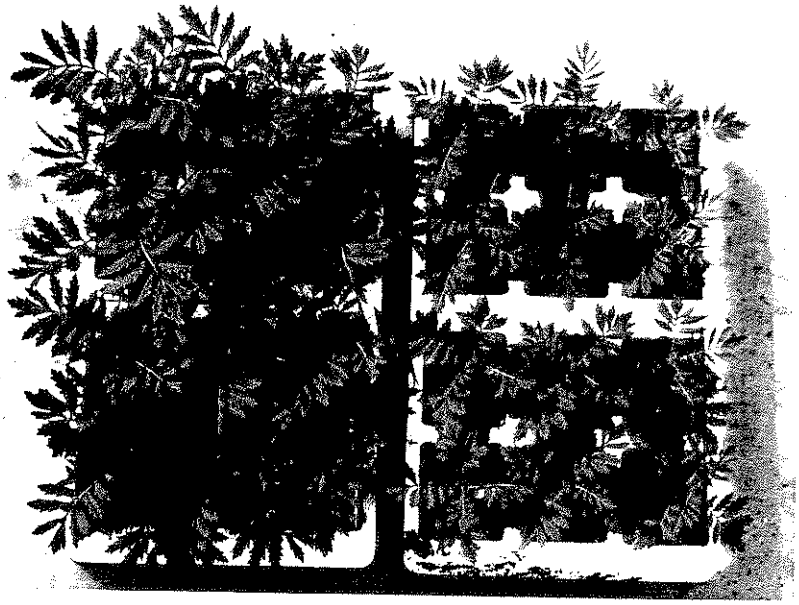
COMMERCIAL - IN CONFIDENCE

APPENDIX V

Plate 5 Marigold : Treatment Comparison at First Records
(control - Levington M2, on left)



Rockwool



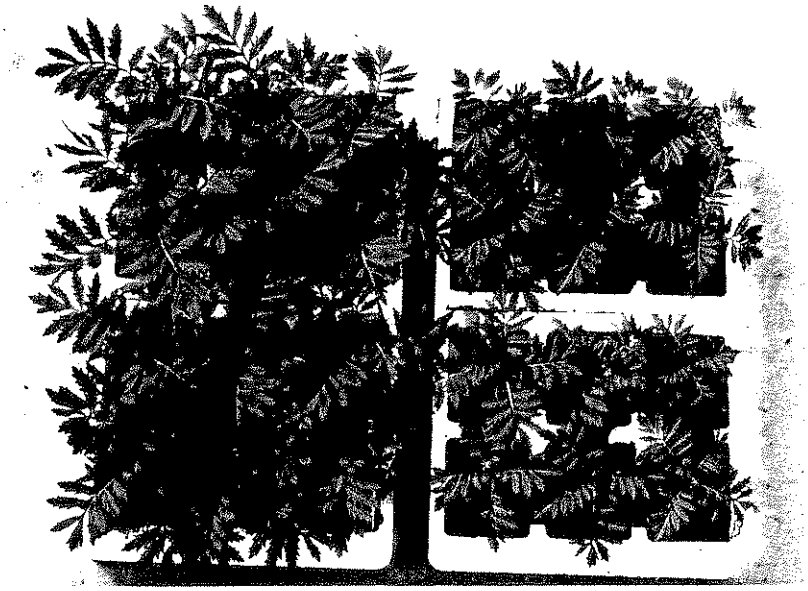
Wessex

SHL

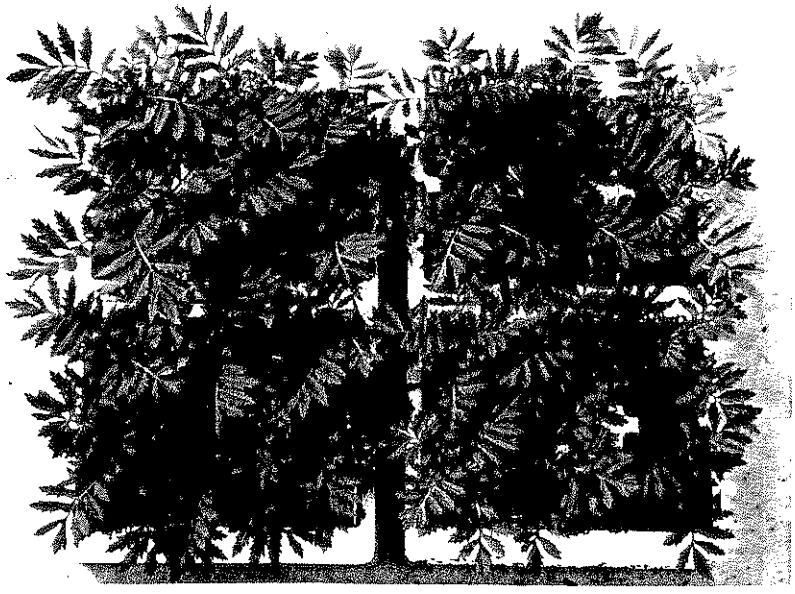
APPENDIX V

Plate 6 Marigold : Treatment Comparison at First Records
(control - Levington M2, on left)

Roffey



Bulrush

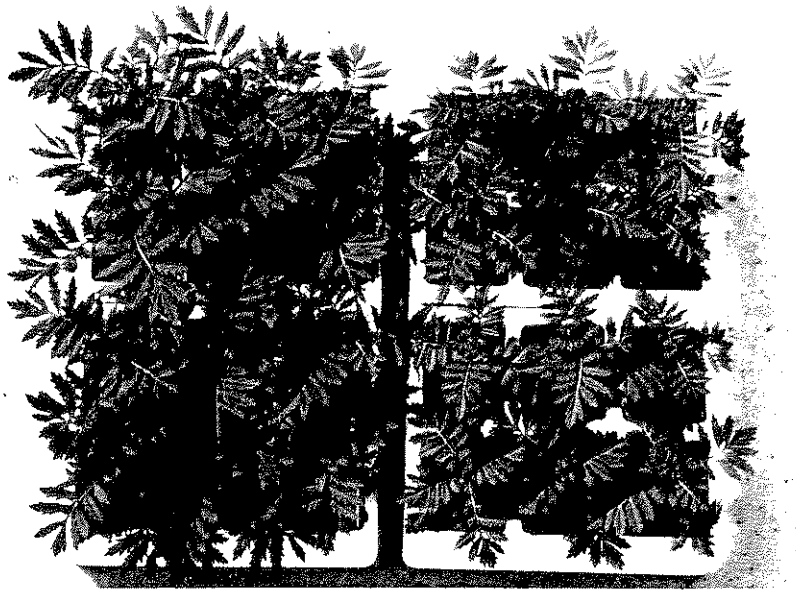


Melcourt

COMMERCIAL - IN CONFIDENCE

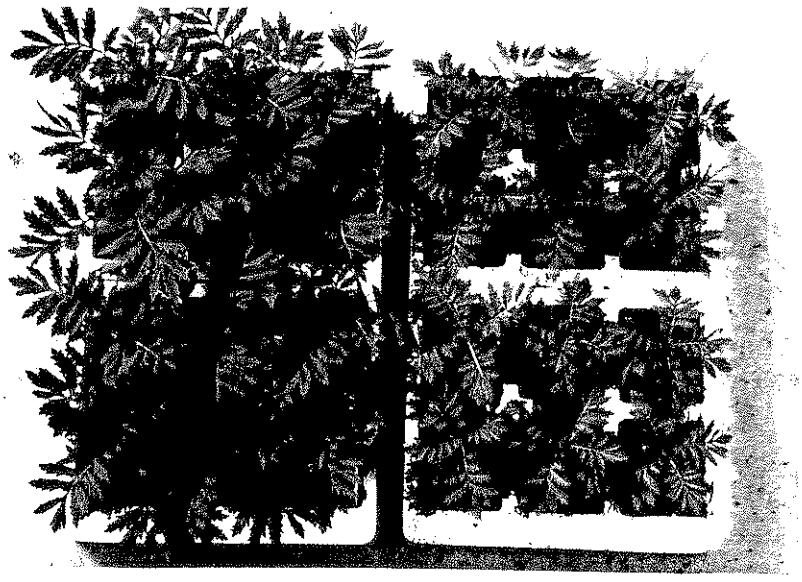
APPENDIX V

Plate 7 Marigold : Treatment Comparison at First Records
(control - Levington M2, on left)



Shamrock

Petersfield

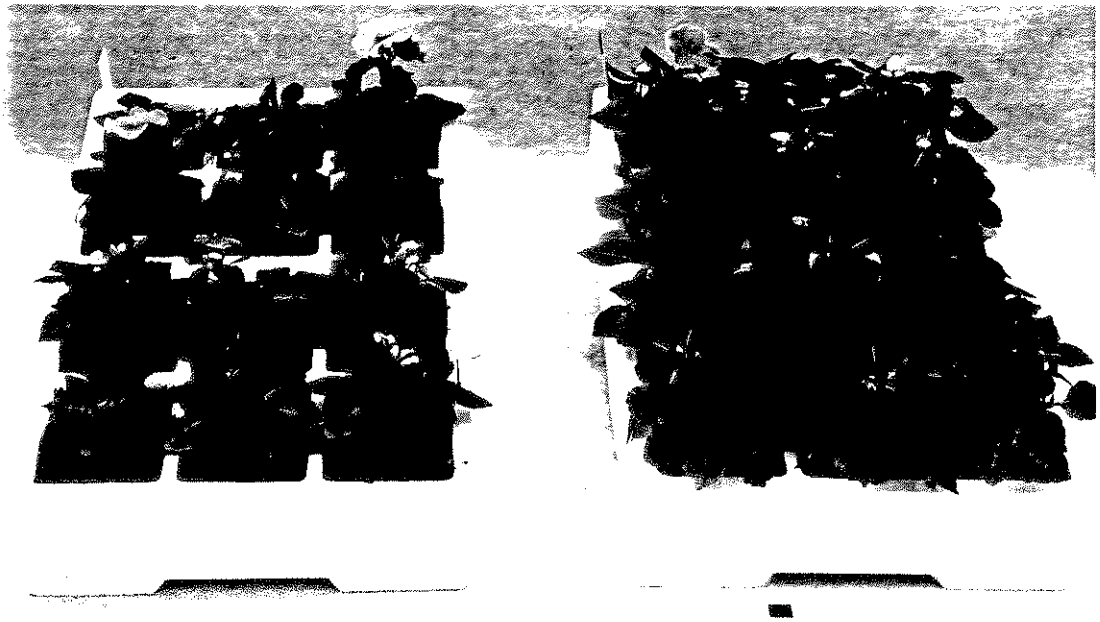


Freeland

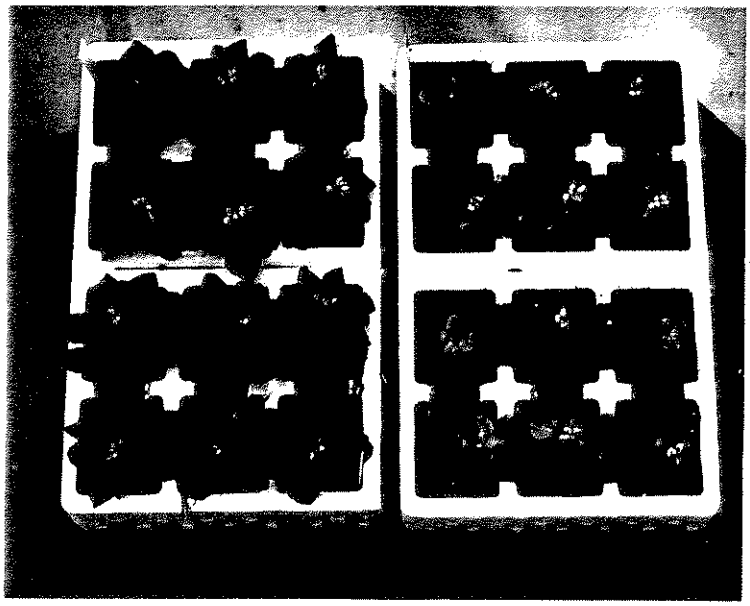
COMMERCIAL - IN CONFIDENCE

APPENDIX V

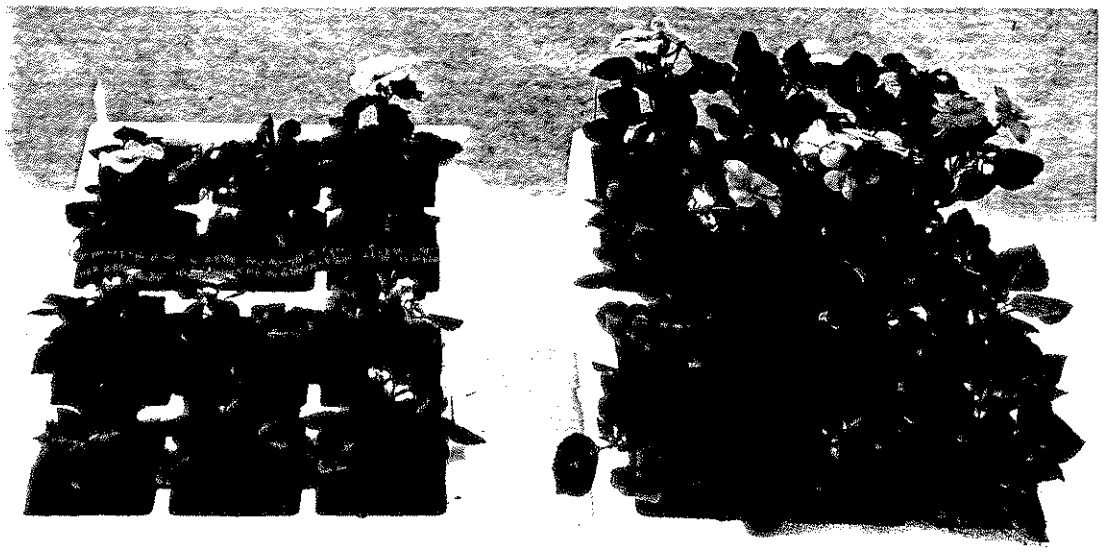
Plate 8 *Impatiens* : Treatment Comparison at First Records
(control - Levington M2, on left)



Grodan



Wessex



SHL

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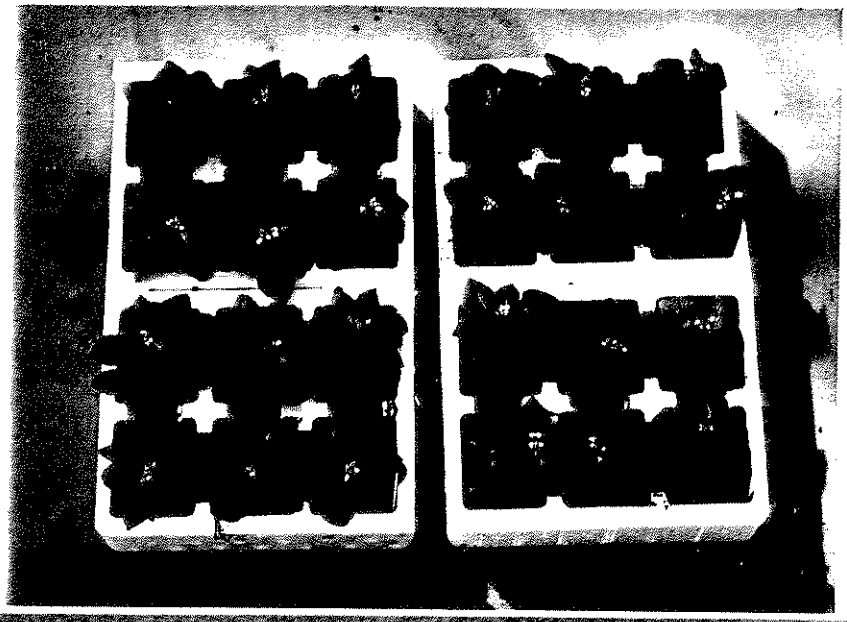
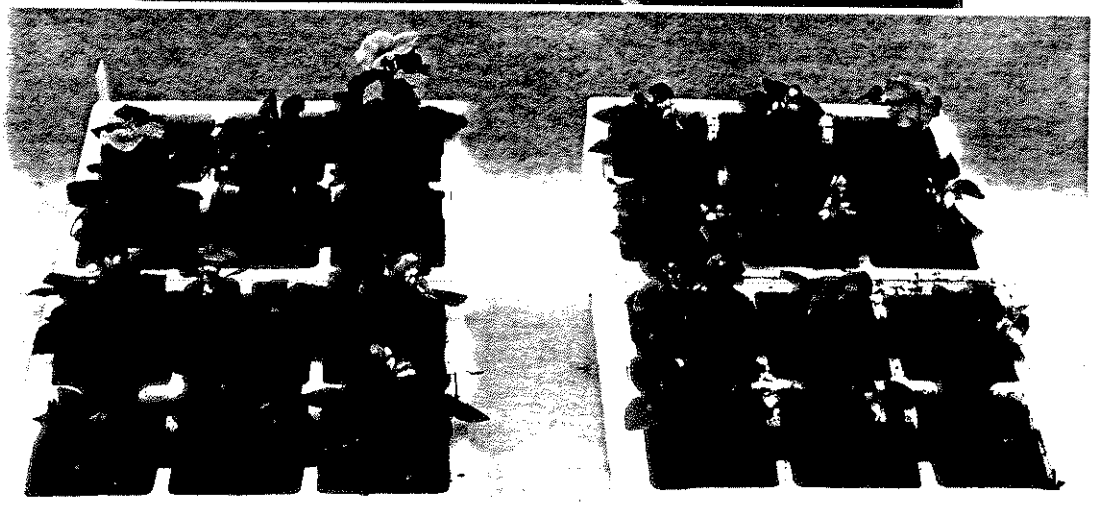
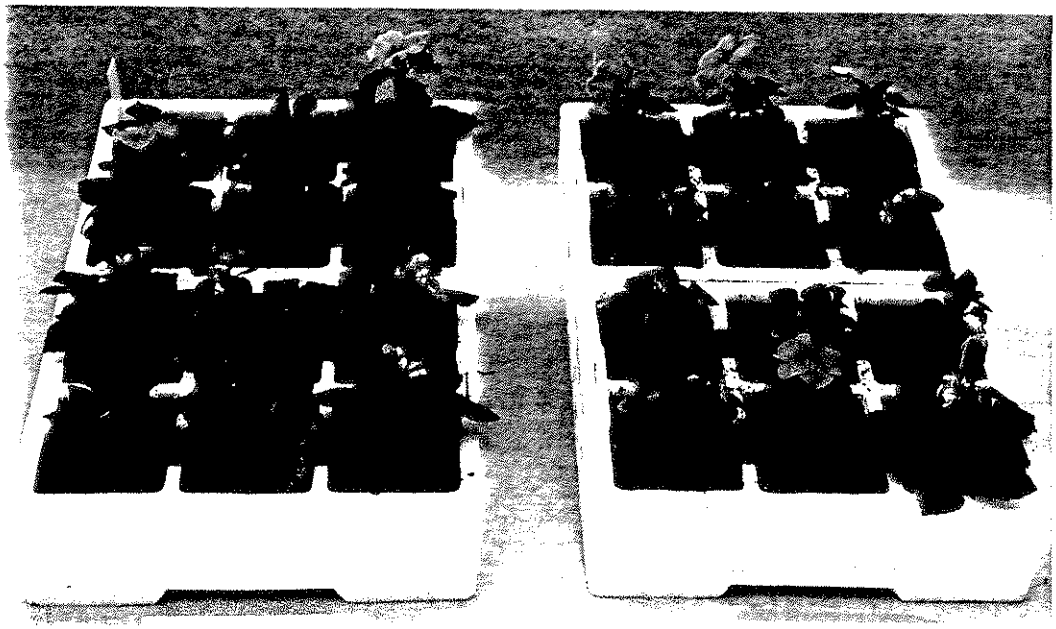
Plate 9 *Impatiens* : Treatment Comparison at First Records
(control - Levington M2, on left)



Roffey



Bulrush



Melcourt

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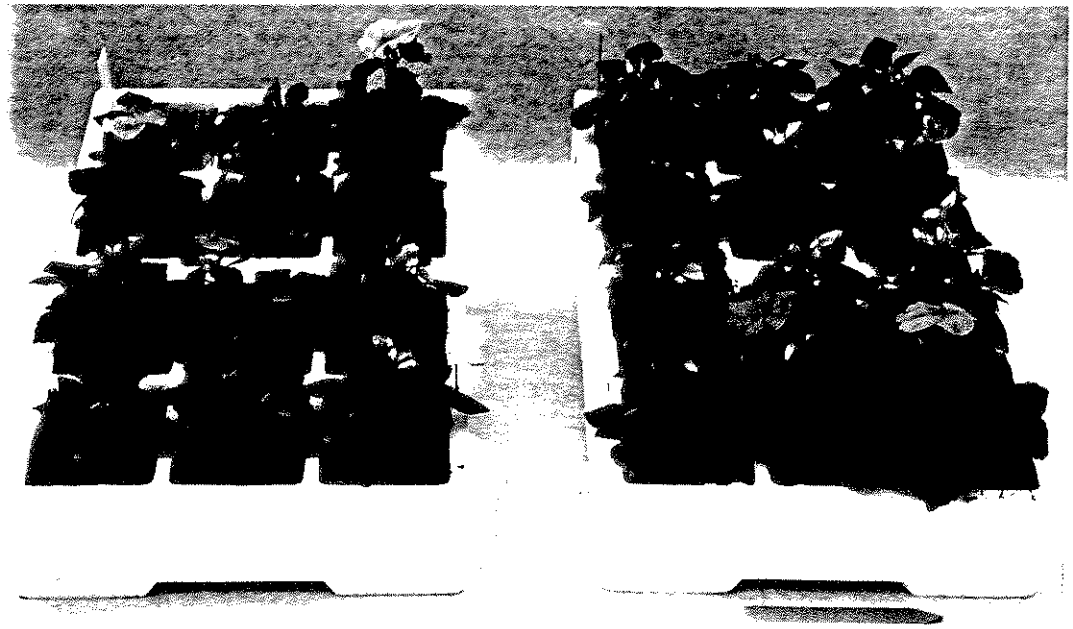
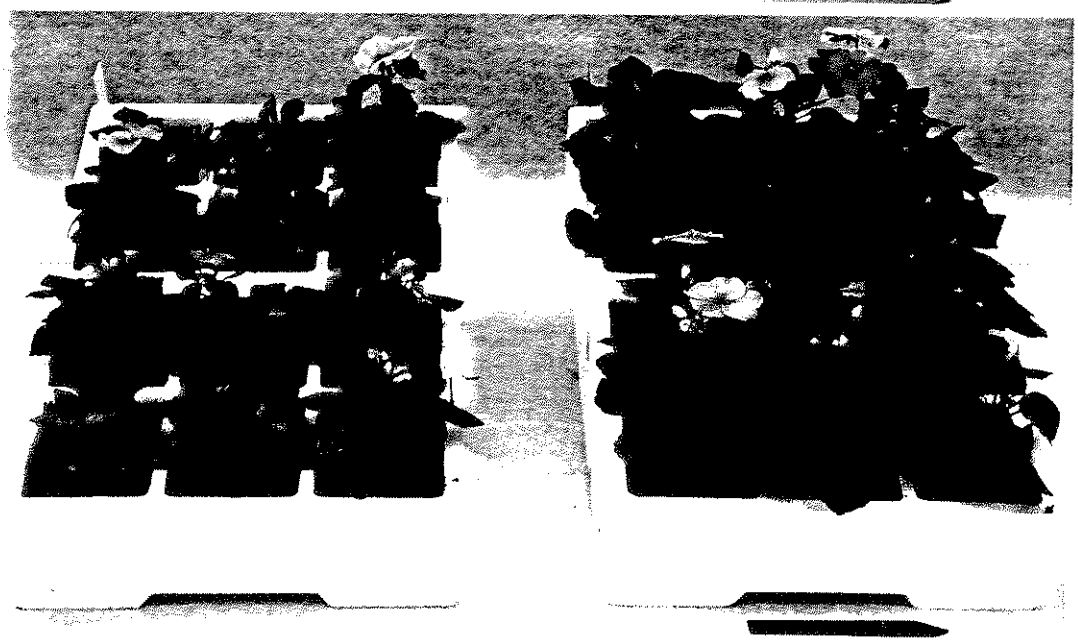
APPENDIX V

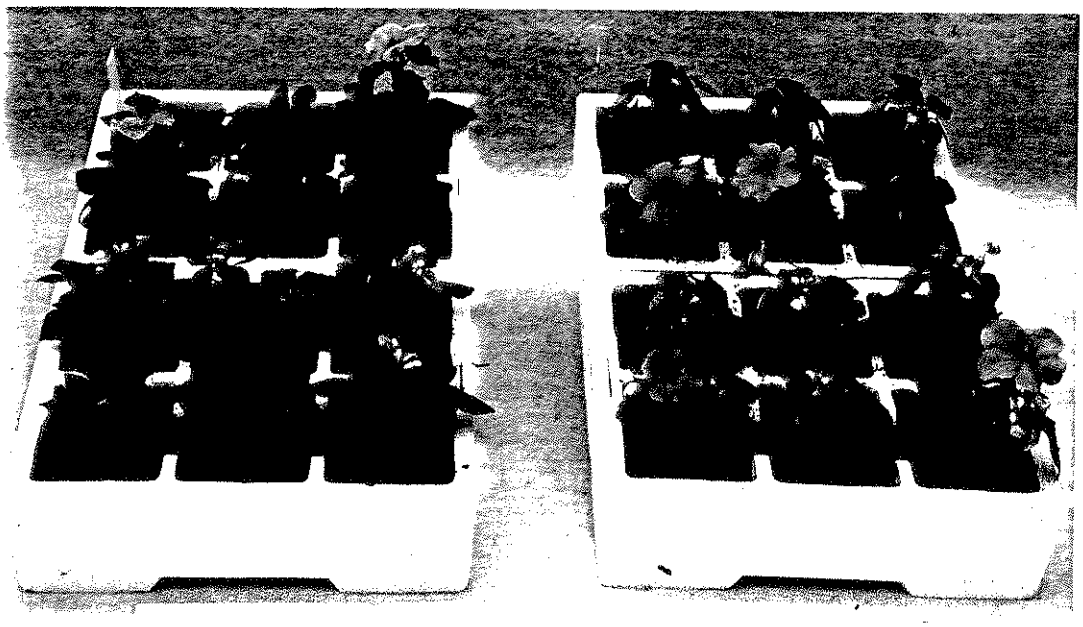
Plate 10 *Impatiens* : Treatment Comparison at First Records
(control - Levington M2, on left)



Shamrock



Petersfield



Freeland

APPENDIX VI

Table 12 Media Analysis of Grodan at First Records for each species (water available - extractable analysis)

		At Potting	Begonia at 4 weeks	Petunia at 4 weeks	Salvia at 4 weeks	Geranium at 5 weeks	Impatiens at 4 weeks	Marigold at 3 weeks
Product: Grodania								
pH		8.3	7.6	8.2	7.8	7.8	8.4	8.5
Conductivity uS/20°C		88.0 (0)	279.0 (1)	92.0 (0)	151.0 (1)	156.0 (1)	102.0 (0)	100.0 (0)
Nitrate (as N)	mg/l	15.0 (1)	61.0 (3)	8.0 (0)	41.0 (2)	33.0 (2)	14.0 (0)	183.0 (5)
Ammonium (as N)	mg/l	5.9 (0)	<0.1 (0)	0.4 (0)	0.9 (0)	0.9 (0)	0.4 (0)	7.5 (0)
Potassium	mg/l	16.0 (0)	100.0 (2)	20.0 (0)	74.0 (2)	52.0 (2)	48.0 (1)	204.0 (4)
Calcium	mg/l	47.0	92.0	62.0	93.0	87.0	59.0	186.0
Magnesium	mg/l	7.0 (1)	17.0 (3)	10.0 (1)	14.0 (2)	22.0 (3)	9.0 (1)	48.0 (5)
Phosphorus	mg/l	1.0 (0)	9.0 (2)	9.0 (2)	11.0 (2)	8.0 (2)	5.0 (1)	98.0 (8)
Iron	mg/l	0.17	6.01	1.39	<0.01	<0.01	2.41	1.76
Zinc	mg/l	0.01	0.12	0.02	0.01	0.01	0.03	3.19
Manganese	mg/l	0.05	0.07	0.02	0.08	0.05	0.02	9.08
Copper	mg/l	0.01	0.02	0.02	0.02	0.01	0.01	0.18
Boron	mg/l	0.07	<0.01	0.07	<0.01	<0.01	<0.01	<0.01
Bulk Density	g/ml	0.130	0.440	0.299	0.637	0.25	0.37	0.392
Product: Control - Levington M2								
pH		5.8	5.9	5.9	5.9	5.8	6.0	5.6
Conductivity uS/20°C		352.0 (2)	330.0 (2)	230.0 (1)	224.0 (1)	255.0 (1)	176.0 (1)	270.0 (1)
Nitrate (as N)	mg/l	114.0 (4)	106.0 (4)	64.0 (3)	53.0 (3)	67.0 (3)	38.0 (2)	74.0 (3)
Ammonium (as N)	mg/l	47.0 (1)	40.2 (1)	0.6 (0)	0.6 (0)	16.0 (0)	0.6 (0)	0.3 (0)
Potassium	mg/l	126.0 (3)	134.0 (3)	46.0 (1)	55.0 (2)	85.0 (2)	67.0 (2)	90.0 (2)
Calcium	mg/l	80.0	80.0	82.0	85.0	69.0	57.0	105.0
Magnesium	mg/l	83.0 (6)	64.0 (6)	75.0 (6)	76.0 (6)	65.0 (6)	50.0 (6)	94.0 (7)
Phosphorus	mg/l	89.0 (8)	82.0 (8)	48.0 (6)	55.0 (7)	66.0 (7)	45.0 (6)	67.0 (7)
Iron	mg/l	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/l	0.23	0.28	0.22	0.16	0.14	0.18	0.09
Manganese	mg/l	0.18	0.16	0.18	0.17	0.28	0.14	0.21
Copper	mg/l	0.08	0.04	0.04	0.06	0.07	0.06	0.07
Boron	mg/l	<0.01	<0.01	<0.01	0.11	<0.01	<0.01	<0.01
Bulk Density	g/ml	0.272	0.367	0.31	0.31	0.264	0.426	0.328

Table 13 Leaf Tissue Analysis at First Records for each species grown in Grodan

		Begonia at 4 weeks	Petunia at 4 weeks	Salvia at 4 weeks	Geranium at 5 weeks	Impatiens at 4 weeks	Marigold at 3 weeks
Product: Grodania							
Nitrogen	%	3.38	N/A	4.96	N/A	4.47	4.19
Phosphorus	%	0.465	N/A	0.587	N/A	0.97	0.67
Potassium	%	3.18	N/A	5.48	N/A	3.91	3.46
Calcium	%	2.156	N/A	1.72	N/A	3.80	2.43
Magnesium	%	1.107	N/A	0.63	N/A	0.77	0.70
Manganese	mg/kg	113.82	N/A	97.10	N/A	120.3	168.6
Product: Control - Levington M2							
Nitrogen	%	4.04	N.A.	4.00	N.A.	4.04	4.16
Phosphorus	%	0.513	N.A.	0.501	N.A.	1.092	1.079
Potassium	%	3.13	N.A.	5.72	N.A.	2.80	5.10
Calcium	%	1.225	N.A.	1.455	N.A.	2.321	1.687
Magnesium	%	0.935	N.A.	1.082	N.A.	1.414	1.390
Manganese	mg/kg	153.64	N.A.	200.40	N.A.	131.68	255.78

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APPENDIX VI

Table 14 Media Analysis of Wessex at First Records for each species (water available - extractable analysis)

		At Potting	Begonia at 4 weeks	Petunia at 4 weeks	Salvia at 4 weeks	Geranium at 5 weeks	Impatiens at 4 weeks	Marigold at 3 weeks
Product: Wessex								
pH		6.2	N.A.	N.A.	N.A.	N.A.	N.A.	7.2
Conductivity uS/20^{0}C		194.0 (1)	N.A.	N.A.	N.A.	N.A.	N.A.	151.0 (1)
Nitrate (as N)	mg/l	1.0 (0)	N.A.	N.A.	N.A.	N.A.	N.A.	7.0 (0)
Ammonium (as N)	mg/l	0.6 (0)	N.A.	N.A.	N.A.	N.A.	N.A.	1.0 (0)
Potassium	mg/l	188.0 (4)	N.A.	N.A.	N.A.	N.A.	N.A.	145.0 (3)
Calcium	mg/l	9.0	N.A.	N.A.	N.A.	N.A.	N.A.	11.0
Magnesium	mg/l	1.0 (0)	N.A.	N.A.	N.A.	N.A.	N.A.	4.0 (0)
Phosphorus	mg/l	11.0 (3)	N.A.	N.A.	N.A.	N.A.	N.A.	13.0 (3)
Iron	mg/l	0.46	N.A.	N.A.	N.A.	N.A.	N.A	4.57
Zinc	mg/l	0.18	N.A.	N.A.	N.A.	N.A.	N.A.	0.13
Manganese	mg/l	0.02	N.A.	N.A.	N.A.	N.A.	N.A.	0.05
Copper	mg/l	0.04	N.A.	N.A.	N.A.	N.A.	N.A.	0.04
Boron	mg/l	0.18	N.A.	N.A.	N.A.	N.A.	N.A.	0.03
Bulk Density	g/ml	0.248	N.A.	N.A.	N.A.	N.A.	N.A.	0.247
Product: Control - Levington M2								
pH		5.8	5.9	5.9	5.9	5.8	6.0	5.6
Conductivity uS/20^{0}C		352.0 (2)	330.0 (2)	230.0 (1)	224.0 (1)	255.0 (1)	176.0 (1)	270.0 (1)
Nitrate (as N)	mg/l	114.0 (4)	106.0 (4)	64.0 (3)	53.0 (3)	67.0 (3)	38.0 (2)	74.0 (3)
Ammonium (as N)	mg/l	47.0 (1)	40.2 (1)	0.6 (0)	0.6 (0)	16.0 (0)	0.6 (0)	0.3 (0)
Potassium	mg/l	126.0 (3)	134.0 (3)	46.0 (1)	55.0 (2)	85.0 (2)	67.0 (2)	90.0 (2)
Calcium	mg/l	80.0	80.0	82.0	85.0	69.0	57.0	105.0
Magnesium	mg/l	83.0 (6)	64.0 (6)	75.0 (6)	76.0 (6)	65.0 (6)	50.0 (6)	94.0 (7)
Phosphorus	mg/l	89.0 (8)	82.0 (8)	48.0 (6)	55.0 (7)	66.0 (7)	45.0 (6)	67.0 (7)
Iron	mg/l	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/l	0.23	0.28	0.22	0.16	0.14	0.18	0.09
Manganese	mg/l	0.18	0.16	0.18	0.17	0.28	0.14	0.21
Copper	mg/l	0.08	0.04	0.04	0.06	0.07	0.06	0.07
Boron	mg/l	<0.01	<0.01	<0.01	0.11	<0.01	<0.01	<0.01
Bulk Density	g/ml	0.272	0.367	0.31	0.31	0.264	0.426	0.328

Table 15 Leaf Tissue Analysis at First Records for each species grown in Wessex

		Begonia at 4 weeks	Petunia at 4 weeks	Salvia af 4 weeks	Geranium at 5 weeks	Impatiens at 4 weeks	Marigold at 3 weeks
Product: Wessex							
Nitrogen	%	N.A.	N.A.	4.23	N.A.	3.85	2.19
Phosphorus	%	N.A.	N.A.	0.516	N.A.	1.027	0.589
Potassium	%	N.A.	N.A.	2.69	N.A.	5.13	3.94
Calcium	%	N.A.	N.A.	1.117	N.A.	1.617	0.901
Magnesium	%	N.A.	N.A.	1.141	N.A.	0.643	0.485
Manganese	mg/kg	N.A.	N.A.	82.41	N.A.	89.39	71.98
Product: Control - Levington M2							
Nitrogen	%	4.04	N.A.	4.00	N.A.	4.04	4.16
Phosphorus	%	0.513	N.A.	0.501	N.A.	1.092	1.079
Potassium	%	3.13	N.A.	5.72	N.A.	2.80	5.10
Calcium	%	1.225	N.A.	1.455	N.A.	2.321	1.687
Magnesium	%	0.935	N.A.	1.082	N.A.	1.414	1.390
Manganese	mg/kg	153.64	N.A.	200.40	N.A.	131.68	255.78

APPENDIX VI

Table 16 **Media Analysis of SHL at First Records for each species (water available - extractable analysis)**

		At Potting	Begonia at 4 weeks	Petunia at 4 weeks	Salvia at 4 weeks	Geranium at 5 weeks	Impatiens at 4 weeks	Marigold at 3 weeks
Product: SHL								
pH		6.5	6.3	6.9	6.6	6.4	6.6	6.7
Conductivity uS/20^{0}C		440.0 (3)	393.0 (2)	151.0 (1)	253.0 (1)	352.0 (2)	258.0 (1)	193.0 (1)
Nitrate (as N)	mg/l	102.0 (4)	61.0 (3)	1.0 (0)	11.0 (0)	52.0 (3)	27.0 (2)	26.0 (2)
Ammonium (as N)	mg/l	70.0 (2)	16.5 (0)	0.7 (0)	10.3 (0)	21.1 (1)	14.7 (0)	1.1 (0)
Potassium	mg/l	410.0 (6)	431.0 (6)	157.0 (3)	271.0 (5)	359.0 (5)	268.0 (5)	203.0 (4)
Calcium	mg/l	12.0	17.0	8.0	12.0	20.0	14.0	12.0
Magnesium	mg/l	8.0 (1)	12.0 (2)	3.0 (0)	5.0 (1)	11.0 (2)	6.0 (1)	4.0 (0)
Phosphorus	mg/l	74.0 (7)	64.0 (7)	25.0 (4)	46.0 (6)	53.0 (6)	42.0 (6)	30.0 (5)
Iron	mg/l	1.75	1.60	1.32	2.24	1.94	1.28	0.63
Zinc	mg/l	3.09	2.59	1.76	2.16	2.49	2.04	1.50
Manganese	mg/l	1.18	1.15	0.37	0.54	0.91	0.57	0.31
Copper	mg/l	1.71	1.23	0.79	1.13	1.14	0.94	0.71
Boron	mg/l	0.33	0.49	0.22	0.38	0.39	0.23	0.31
Bulk Density	g/ml	0.297	0.25	0.318	0.264	0.27	0.29	0.294
Product: Control - Levington M2								
pH		5.8	5.9	5.9	5.9	5.8	6.0	5.6
Conductivity uS/20^{0}C		352.0 (2)	330.0 (2)	230.0 (1)	224.0 (1)	255.0 (1)	176.0 (1)	270.0 (1)
Nitrate (as N)	mg/l	114.0 (4)	106.0 (4)	64.0 (3)	53.0 (3)	67.0 (3)	38.0 (2)	74.0 (3)
Ammonium (as N)	mg/l	47.0 (1)	40.2 (1)	0.6 (0)	0.6 (0)	16.0 (0)	0.6 (0)	0.3 (0)
Potassium	mg/l	126.0 (3)	134.0 (3)	46.0 (1)	55.0 (2)	85.0 (2)	67.0 (2)	90.0 (2)
Calcium	mg/l	80.0	80.0	82.0	85.0	69.0	57.0	105.0
Magnesium	mg/l	83.0 (6)	64.0 (6)	75.0 (6)	76.0 (6)	65.0 (6)	50.0 (6)	94.0 (7)
Phosphorus	mg/l	89.0 (8)	82.0 (8)	48.0 (6)	55.0 (7)	66.0 (7)	45.0 (6)	67.0 (7)
Iron	mg/l	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/l	0.23	0.28	0.22	0.16	0.14	0.18	0.09
Manganese	mg/l	0.18	0.16	0.18	0.17	0.28	0.14	0.21
Copper	mg/l	0.08	0.04	0.04	0.06	0.07	0.06	0.07
Boron	mg/l	<0.01	<0.01	<0.01	0.11	<0.01	<0.01	<0.01
Bulk Density	g/ml	0.272	0.367	0.31	0.31	0.264	0.426	0.328

Table 17 **Leaf Tissue Analysis at First Records for each species grown in SHL**

		Begonia at 4 weeks	Petunia at 4 weeks	Salvia at 4 weeks	Geranium at 5 weeks	Impatiens at 4 weeks	Marigold at 3 weeks
Product: SHL							
Nitrogen	%	3.67	N.A.	5.49	N.A.	4.82	4.20
Phosphorus	%	0.543	N.A.	0.673	N.A.	1.146	1.349
Potassium	%	3.40	N.A.	5.30	N.A.	5.37	6.55
Calcium	%	0.671	N.A.	0.563	N.A.	1.146	0.994
Magnesium	%	0.623	N.A.	0.711	N.A.	0.699	0.813
Manganese	mg/kg	104.71	N.A.	148.91	N.A.	137.33	273.25
Product: Control - Levington M2							
Nitrogen	%	4.04	N.A.	4.00	N.A.	4.04	4.16
Phosphorus	%	0.513	N.A.	0.501	N.A.	1.092	1.079
Potassium	%	3.13	N.A.	5.72	N.A.	2.80	5.10
Calcium	%	1.225	N.A.	1.455	N.A.	2.321	1.687
Magnesium	%	0.935	N.A.	1.082	N.A.	1.414	1.390
Manganese	mg/kg	153.64	N.A.	200.40	N.A.	131.68	255.78

APPENDIX VI

Table 18 **Media Analysis of Roffey at First Records for each species (water available - extractable analysis)**

		At Potting	Begonia at 4 weeks	Petunia at 4 weeks	Salvia at 4 weeks	Geranium at 5 weeks	Impatiens at 4 weeks	Marigold at 3 weeks
Product: Roffey								
pH		5.5	5.6	5.9	5.6	5.7	5.5	6.1
Conductivity uS/20°C		414.0 (3)	249.0 (1)	235.0 (1)	207.0 (1)	281.0 (1)	314.0 (2)	276.0 (1)
Nitrate (as N)	mg/l	202.0 (6)	118.0 (4)	84.0 (4)	72.0 (3)	123.0 (4)	147.0 (5)	56.0 (3)
Ammonium (as N)	mg/l	40.0 (1)	0.3 (0)	0.6 (0)	0.8 (0)	0.6 (0)	0.7 (0)	1.1 (0)
Potassium	mg/l	251.0 (5)	169.0 (3)	91.0 (2)	100.0 (3)	156.0 (3)	194.0 (4)	203.0 (4)
Calcium	mg/l	55.0	54.0	54.0	48.0	64.0	70.0	58.0
Magnesium	mg/l	59.0 (6)	38.0 (5)	47.0 (5)	38.0 (5)	51.0 (6)	58.0 (6)	20.0 (3)
Phosphorus	mg/l	70.0 (7)	45.0 (6)	49.0 (6)	42.0 (6)	44.0 (6)	48.0 (6)	16.0 (3)
Iron	mg/l	1.44	1.18	0.58	0.88	0.99	1.66	7.90
Zinc	mg/l	0.59	0.36	0.53	0.31	0.32	0.33	0.82
Manganese	mg/l	0.53	0.25	0.09	0.20	0.30	0.50	0.60
Copper	mg/l	0.12	0.04	0.06	0.08	0.08	0.05	0.12
Boron	mg/l	<0.01	<0.01	0.02	0.04	0.23	0.15	0.07
Bulk Density	g/ml	0.28	0.26	0.33	0.285	0.234	0.30	0.221
Product: Control - Levington M2								
pH		5.8	5.9	5.9	5.9	5.8	6.0	5.6
Conductivity uS/20°C		352.0 (2)	330.0 (2)	230.0 (1)	224.0 (1)	255.0 (1)	176.0 (1)	270.0 (1)
Nitrate (as N)	mg/l	114.0 (4)	106.0 (4)	64.0 (3)	53.0 (3)	67.0 (3)	38.0 (2)	74.0 (3)
Ammonium (as N)	mg/l	47.0 (1)	40.2 (1)	0.6 (0)	0.6 (0)	16.0 (0)	0.6 (0)	0.3 (0)
Potassium	mg/l	126.0 (3)	134.0 (3)	46.0 (1)	55.0 (2)	85.0 (2)	67.0 (2)	90.0 (2)
Calcium	mg/l	80.0	80.0	82.0	85.0	69.0	57.0	105.0
Magnesium	mg/l	83.0 (6)	64.0 (6)	75.0 (6)	76.0 (6)	65.0 (6)	50.0 (6)	94.0 (7)
Phosphorus	mg/l	89.0 (8)	82.0 (8)	48.0 (6)	55.0 (7)	66.0 (7)	45.0 (6)	67.0 (7)
Iron	mg/l	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/l	0.23	0.28	0.22	0.16	0.14	0.18	0.09
Manganese	mg/l	0.18	0.16	0.18	0.17	0.28	0.14	0.21
Copper	mg/l	0.08	0.04	0.04	0.06	0.07	0.06	0.07
Boron	mg/l	<0.01	<0.01	<0.01	0.11	<0.01	<0.01	<0.01
Bulk Density	g/ml	0.272	0.367	0.31	0.31	0.264	0.426	0.328

Table 19 **Leaf Tissue Analysis at First Records for each species grown in Roffey**

		Begonia at 4 weeks	Petunia at 4 weeks	Salvia at 4 weeks	Geranium at 5 weeks	Impatiens at 4 weeks	Marigold at 3 weeks
Product: Roffey							
Nitrogen	%	3.60	N.A.	4.59	N.A.	4.30	4.40
Phosphorus	%	0.568	N.A.	0.569	N.A.	0.983	1.136
Potassium	%	3.53	N.A.	5.39	N.A.	3.74	4.50
Calcium	%	1.095	N.A.	1.273	N.A.	2.060	1.705
Magnesium	%	1.165	N.A.	0.982	N.A.	1.251	1.498
Manganese	mg/kg	81.86	N.A.	223.11	N.A.	205.67	371.32
Product: Control - Levington M2							
Nitrogen	%	4.04	N.A.	4.00	N.A.	4.04	4.16
Phosphorus	%	0.513	N.A.	0.501	N.A.	1.092	1.079
Potassium	%	3.13	N.A.	5.72	N.A.	2.80	5.10
Calcium	%	1.225	N.A.	1.455	N.A.	2.321	1.687
Magnesium	%	0.935	N.A.	1.082	N.A.	1.414	1.390
Manganese	mg/kg	153.64	N.A.	200.40	N.A.	131.68	255.78

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Table 20 **Media Analysis of Bulrush at First Records for each species (water available - extractable analysis)**

		At Potting	Begonia at 4 weeks	Petunia at 4 weeks	Salvia at 4 weeks	Geranium at 5 weeks	Impatiens at 4 weeks	Marigold at 3 weeks
Product: Bulrush								
pH		6.9	6.8	7.1	7.1	7.0	7.3	7.1
Conductivity uS/20°C		668.0 (5)	218.0 (1)	416.0 (3)	470.0 (3)	459.0 (3)	345.0 (2)	416.0 (3)
Nitrate (as N)	mg/l	177.0 (5)	176.0 (5)	68.0 (3)	99.0 (4)	108.0 (4)	35.0 (2)	102.0 (4)
Ammonium (as N)	mg/l	16.0 (0)	13.3 (0)	8.2 (0)	6.2 (0)	14.8 (0)	0.4 (0)	17.6 (0)
Potassium	mg/l	71.0 (2)	73.0 (2)	47.0 (1)	48.0 (1)	60.0 (2)	46.0 (1)	52.0 (2)
Calcium	mg/l	385.0	384.0	225.0	268.0	243.0	183.0	208.0
Magnesium	mg/l	231.0 (9)	197.0 (8)	129.0 (7)	148.0 (7)	147.0 (7)	102.0 (2)	132.0 (7)
Phosphorus	mg/l	11.0 (2)	12.0 (3)	5.0 (1)	5.0 (1)	8.0 (2)	4.0 (0)	6.0 (1)
Iron	mg/l	0.90	0.47	<0.01	0.01	<0.01	<0.01	0.09
Zinc	mg/l	0.63	0.65	0.43	0.41	0.62	0.41	0.27
Manganese	mg/l	4.86	4.40	3.07	3.25	3.12	2.59	2.43
Copper	mg/l	0.31	0.19	0.09	0.10	0.10	0.08	0.09
Boron	mg/l	<0.01	<0.01	<0.01	<0.01	0.21	<0.01	0.06
Bulk Density	g/ml	0.653	0.665	0.59	0.624	0.62	0.635	0.612
Product: Control - Levington M2								
pH		5.8	5.9	5.9	5.9	5.8	6.0	5.6
Conductivity uS/20°C		352.0 (2)	330.0 (2)	230.0 (1)	224.0 (1)	255.0 (1)	176.0 (1)	270.0 (1)
Nitrate (as N)	mg/l	114.0 (4)	106.0 (4)	64.0 (3)	53.0 (3)	67.0 (3)	38.0 (2)	74.0 (3)
Ammonium (as N)	mg/l	47.0 (1)	40.2 (1)	0.6 (0)	0.6 (0)	16.0 (0)	0.6 (0)	0.3 (0)
Potassium	mg/l	126.0 (3)	134.0 (3)	46.0 (1)	55.0 (2)	85.0 (2)	67.0 (2)	90.0 (2)
Calcium	mg/l	80.0	80.0	82.0	85.0	69.0	57.0	105.0
Magnesium	mg/l	83.0 (6)	64.0 (6)	75.0 (6)	76.0 (6)	65.0 (6)	50.0 (6)	94.0 (7)
Phosphorus	mg/l	89.0 (8)	82.0 (8)	48.0 (6)	55.0 (7)	66.0 (7)	45.0 (6)	67.0 (7)
Iron	mg/l	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/l	0.23	0.28	0.22	0.16	0.14	0.18	0.09
Manganese	mg/l	0.18	0.16	0.18	0.17	0.28	0.14	0.21
Copper	mg/l	0.08	0.04	0.04	0.06	0.07	0.06	0.07
Boron	mg/l	<0.01	<0.01	<0.01	0.11	<0.01	<0.01	<0.01
Bulk Density	g/ml	0.272	0.367	0.31	0.31	0.264	0.426	0.328

Table 21 **Leaf Tissue Analysis at First Records for each species grown in Bulrush**

		Begonia at 4 weeks	Petunia at 4 weeks	Salvia at 4 weeks	Geranium at 5 weeks	Impatiens at 4 weeks	Marigold at 3 weeks
Product: Bulrush							
Nitrogen	%	2.84	N.A.	4.61	N.A.	4.23	4.04
Phosphorus	%	0.317	N.A.	0.402	N.A.	0.614	0.536
Potassium	%	1.98	N.A.	3.92	N.A.	2.46	3.52
Calcium	%	1.642	N.A.	1.617	N.A.	3.338	2.084
Magnesium	%	1.518	N.A.	1.101	N.A.	1.375	1.275
Manganese	mg/kg	222.90	N.A.	312.70	N.A.	343.20	695.63
Product: Control - Levington M2							
Nitrogen	%	4.04	N.A.	4.00	N.A.	4.04	4.16
Phosphorus	%	0.513	N.A.	0.501	N.A.	1.092	1.079
Potassium	%	3.13	N.A.	5.72	N.A.	2.80	5.10
Calcium	%	1.225	N.A.	1.455	N.A.	2.321	1.687
Magnesium	%	0.935	N.A.	1.082	N.A.	1.414	1.390
Manganese	mg/kg	153.64	N.A.	200.40	N.A.	131.68	255.78

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Table 22 **Media Analysis of Melcourt at First Records for each species (water available - extractable analysis)**

		At Potting	Begonia at 4 weeks	Petunia at 4 weeks	Salvia at 4 weeks	Geranium at 5 weeks	Impatiens at 4 weeks	Marigold at 3 weeks
Product: Melcourt								
pH		5.7	5.8	6.0	5.9	5.7	5.9	5.8
Conductivity uS/20°C		590.0 (4)	451.0 (3)	403.0 (3)	420.0 (3)	528.0 (4)	528.0 (4)	492.0 (3)
Nitrate (as N)	mg/l	192.0 (5)	143.0 (5)	98.0 (4)	131.0 (5)	149.0 (5)	162.0 (5)	123.0 (4)
Ammonium (as N)	mg/l	34.0 (1)	11.0 (0)	18.3 (0)	25.6 (1)	9.4 (0)	21.1 (1)	0.6 (0)
Potassium	mg/l	451.0 (6)	433.0 (6)	323.0 (5)	323.0 (5)	425.0 (6)	443.0 (6)	409.0 (6)
Calcium	mg/l	252.0	173.0	170.0	214.0	247.0	221.0	214.0
Magnesium	mg/l	55.0 (6)	37.0 (5)	40.0 (5)	53.0 (6)	64.0 (6)	48.0 (5)	55.0 (6)
Phosphorus	mg/l	108.0 (9)	92.0 (8)	77.0 (8)	92.0 (8)	96.0 (8)	98.0 (8)	96.0 (8)
Iron	mg/l	<0.01	0.81	<0.01	0.06	0.19	0.58	0.60
Zinc	mg/l	0.47	0.32	0.35	0.28	0.35	0.27	0.24
Manganese	mg/l	7.88	4.30	3.95	4.94	5.89	5.50	4.53
Copper	mg/l	0.12	0.04	0.05	0.06	0.06	0.04	0.11
Boron	mg/l	<0.01	<0.01	0.19	<0.01	0.01	<0.01	0.19
Bulk Density	g/ml	0.369	0.40	0.37	0.39	0.36	0.39	0.396
Product: Control - Levington M2								
pH		5.8	5.9	5.9	5.9	5.8	6.0	5.6
Conductivity uS/20°C		352.0 (2)	330.0 (2)	230.0 (1)	224.0 (1)	255.0 (1)	176.0 (1)	270.0 (1)
Nitrate (as N)	mg/l	114.0 (4)	106.0 (4)	64.0 (3)	53.0 (3)	67.0 (3)	38.0 (2)	74.0 (3)
Ammonium (as N)	mg/l	47.0 (1)	40.2 (1)	0.6 (0)	0.6 (0)	16.0 (0)	0.6 (0)	0.3 (0)
Potassium	mg/l	126.0 (3)	134.0 (3)	46.0 (1)	55.0 (2)	85.0 (2)	67.0 (2)	90.0 (2)
Calcium	mg/l	80.0	80.0	82.0	85.0	69.0	57.0	105.0
Magnesium	mg/l	83.0 (6)	64.0 (6)	75.0 (6)	76.0 (6)	65.0 (6)	50.0 (6)	94.0 (7)
Phosphorus	mg/l	89.0 (8)	82.0 (8)	48.0 (6)	55.0 (7)	66.0 (7)	45.0 (6)	67.0 (7)
Iron	mg/l	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/l	0.23	0.28	0.22	0.16	0.14	0.18	0.09
Manganese	mg/l	0.18	0.16	0.18	0.17	0.28	0.14	0.21
Copper	mg/l	0.08	0.04	0.04	0.06	0.07	0.06	0.07
Boron	mg/l	<0.01	<0.01	<0.01	0.11	<0.01	<0.01	<0.01
Bulk Density	g/ml	0.272	0.367	0.31	0.31	0.264	0.426	0.328

Table 23 **Leaf Tissue Analysis at First Records for each species grown in Melcourt**

		Begonia at 4 weeks	Petunia at 4 weeks	Salvia at 4 weeks	Geranium at 5 weeks	Impatiens at 4 weeks	Marigold at 3 weeks
Product: Melcourt							
Nitrogen	%	3.47	N.A.	4.45	N.A.	3.96	4.21
Phosphorus	%	0.512	N.A.	0.503	N.A.	0.869	0.778
Potassium	%	4.03	N.A.	6.57	N.A.	5.03	6.29
Calcium	%	1.392	N.A.	1.374	N.A.	3.103	1.719
Magnesium	%	0.958	N.A.	0.554	N.A.	0.786	0.674
Manganese	mg/kg	406.76	N.A.	593.74	N.A.	619.55	924.98
Product: Control - Levington M2							
Nitrogen	%	4.04	N.A.	4.00	N.A.	4.04	4.16
Phosphorus	%	0.513	N.A.	0.501	N.A.	1.092	1.079
Potassium	%	3.13	N.A.	5.72	N.A.	2.80	5.10
Calcium	%	1.225	N.A.	1.455	N.A.	2.321	1.687
Magnesium	%	0.935	N.A.	1.082	N.A.	1.414	1.390
Manganese	mg/kg	153.64	N.A.	200.40	N.A.	131.68	255.78

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Table 24 **Media Analysis of Shamrock at First Records for each species (water available - extractable analysis)**

		At Potting	Begonia at 4 weeks	Petunia at 4 weeks	Salvia at 4 weeks	Geranium at 5 weeks	Impatiens at 4 weeks	Marigold at 3 weeks
Product: Shamrock								
pH		5.5	5.8	6.1	6.0	5.8	6.2	5.8
Conductivity uS/20°C		435.0 (3)	325.0 (2)	230.0 (1)	322.0 (2)	345.0 (2)	207.0 (1)	368.0 (2)
Nitrate (as N)	mg/l	253.0 (6)	178.0 (5)	114.0 (4)	172.0 (5)	189.0 (5)	98.0 (4)	21.0 (1)
Ammonium (as N)	mg/l	0.9 (0)	0.3 (0)	0.4 (0)	0.5 (0)	0.9 (0)	0.6 (0)	0.3 (0)
Potassium	mg/l	244.0 (4)	211.0 (4)	121.0 (4)	173.0 (3)	197.0 (4)	143.0 (3)	59.0 (2)
Calcium	mg/l	241.0	156.0	121.0	180.0	171.0	92.0	48.0
Magnesium	mg/l	52.0 (6)	37.0 (5)	29.0 (4)	42.0 (5)	51.0 (6)	22.0 (3)	9.0 (1)
Phosphorus	mg/l	100.0 (9)	78.0 (8)	67.0 (7)	79.0 (8)	81.0 (8)	55.0 (7)	8.0 (2)
Iron	mg/	l2.45	1.38	1.15	1.89	1.83	0.60	7.40
Zinc	mg/l	2.50	2.67	2.95	2.80	2.72	2.33	0.07
Manganese	mg/l	12.21	7.39	5.76	8.57	8.08	3.85	0.05
Copper	mg/l	0.31	0.19	0.25	0.24	0.25	0.21	0.02
Boron	mg/l	<0.01	<0.01	<0.01	<0.01	0.07	<0.01	0.24
Bulk Density	g/ml	0.373	0.33	0.352	0.34	0.31	0.38	0.333
Product: Control - Levington M2								
pH		5.8	5.9	5.9	5.9	5.8	6.0	5.6
Conductivity uS/20°C		352.0 (2)	330.0 (2)	230.0 (1)	224.0 (1)	255.0 (1)	176.0 (1)	270.0 (1)
Nitrate (as N)	mg/l	114.0 (4)	106.0 (4)	64.0 (3)	53.0 (3)	67.0 (3)	38.0 (2)	74.0 (3)
Ammonium (as N)	mg/l	47.0 (1)	40.2 (1)	0.6 (0)	0.6 (0)	16.0 (0)	0.6 (0)	0.3 (0)
Potassium	mg/l	126.0 (3)	134.0 (3)	46.0 (1)	55.0 (2)	85.0 (2)	67.0 (2)	90.0 (2)
Calcium	mg/l	80.0	80.0	82.0	85.0	69.0	57.0	105.0
Magnesium	mg/l	83.0 (6)	64.0 (6)	75.0 (6)	76.0 (6)	65.0 (6)	50.0 (6)	94.0 (7)
Phosphorus	mg/l	89.0 (8)	82.0 (8)	48.0 (6)	55.0 (7)	66.0 (7)	45.0 (6)	67.0 (7)
Iron	mg/l	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.23	0.28	0.22	0.16	0.14	0.18	0.09	
Manganese	mg/l	0.18	0.16	0.18	0.17	0.28	0.14	0.21
Copper	mg/l	0.08	0.04	0.04	0.06	0.07	0.06	0.07
Boron	mg/l	<0.01	<0.01	<0.01	0.11	<0.01	<0.01	<0.01
Bulk Density	g/ml	0.272	0.367	0.31	0.31	0.264	0.426	0.328

Table 25 **Leaf Tissue Analysis at First Records for each species grown in Shamrock**

		Begonia at 4 weeks	Petunia at 4 weeks	Salvia at 4 weeks	Geranium at 5 weeks	Impatiens at 4 weeks	Marigold at 3 weeks
Product: Shamrock							
Nitrogen	%	2.92	N.A.	4.92	N.A.	4.17	3.61
Phosphorus	%	0.450	N.A.	0.514	N.A.	0.959	0.860
Potassium	%	3.24	N.A.	6.14	N.A.	3.57	3.57
Calcium	%	1.631	N.A.	1.940	N.A.	3.822	2.514
Magnesium	%	0.851	N.A.	0.610	N.A.	0.840	0.771
Manganese	mg/kg	556.11	N.A.	799.26	N.A.	1140.37	1356.96
Product: Control - Levington M2							
Nitrogen	%	4.04	N.A.	4.00	N.A.	4.04	4.16
Phosphorus	%	0.513	N.A.	0.501	N.A.	1.092	1.079
Potassium	%	3.13	N.A.	5.72	N.A.	2.80	5.10
Calcium	%	1.225	N.A.	1.455	N.A.	2.321	1.687
Magnesium	%	0.935	N.A.	1.082	N.A.	1.414	1.390
Manganese	mg/kg	153.64	N.A.	200.40	N.A.	131.68	255.78

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Table 26 Media Analysis of Petersfield at First Records for each species (water available - extractable analysis)

		At Potting	Begonia at 4 weeks	Petunia at 4 weeks	Salvia at 4 weeks	Geranium at 5 weeks	Impatiens at 4 weeks	Marigold at 3 weeks
Product: Petersfield								
pH		6.2	6.0	6.4	6.4	6.3	6.6	5.9
Conductivity uS/20°C		401.0 (3)	205.0 (1)	229.0 (1)	314.0 (2)	276.0 (1)	231.0 (1)	276.0 (1)
Nitrate (as N)	mg/l	114.0 (4)	50.0 (2)	34.0 (2)	49.0 (2)	56.0 (3)	36.0 (2)	92.0 (4)
Ammonium (as N)	mg/l	78.0 (2)	17.5 (0)	387.0 (1)	49.4 (1)	27.0 (1)	46.6 (1)	0.8 (0)
Potassium	mg/l	277.0 (5)	197.0 (4)	186.0 (4)	230.0 (4)	208.0 (4)	191.0 (4)	184.0 (4)
Calcium	mg/l	52.0	33.0	47.0	47.0	50.0	30.0	35.0
Magnesium	mg/l	16.0 (3)	9.0 (1)	15.0 (2)	15.0 (3)	18.0 (3)	9.0 (1)	37.0 (5)
Phosphorus	mg/l	44.0 (6)	32.0 (5)	33.0 (5)	32.0 (5)	27.0 (4)	28.0 (4)	49.0 (6)
Iron	mg/l	6.46	8.38	2.78	7.98	8.08	5.88	0.62
Zinc	mg/l	0.63	0.39	0.75	0.67	0.52	0.58	0.84
Manganese	mg/l	0.93	0.37	0.48	0.35	0.47	0.26	0.12
Copper	mg/l	0.29	0.11	0.32	0.26	0.16	0.23	0.05
Boron	mg/l	0.13	0.28	0.02	0.09	0.05	<0.01	0.09
Bulk Density	g/ml	0.457	0.434	0.468	0.44	0.423	0.47	0.441
Product: Control - Levington M2								
pH		5.8	5.9	5.9	5.9	5.8	6.0	5.6
Conductivity uS/20°C		352.0 (2)	330.0 (2)	230.0 (1)	224.0 (1)	255.0 (1)	176.0 (1)	270.0 (1)
Nitrate (as N)	mg/l	114.0 (4)	106.0 (4)	64.0 (3)	53.0 (3)	67.0 (3)	38.0 (2)	74.0 (3)
Ammonium (as N)	mg/l	47.0 (1)	40.2 (1)	0.6 (0)	0.6 (0)	16.0 (0)	0.6 (0)	0.3
Potassium	mg/l	126.0 (3)	134.0 (3)	46.0 (1)	55.0 (2)	85.0 (2)	67.0 (2)	90.0 (2)
Calcium	mg/l	80.0	80.0	82.0	85.0	69.0	57.0	105.0
Magnesium	mg/l	83.0 (6)	64.0 (6)	75.0 (6)	76.0 (6)	65.0 (6)	50.0 (6)	94.0 (7)
Phosphorus	mg/l	89.0 (8)	82.0 (8)	48.0 (6)	55.0 (7)	66.0 (7)	45.0 (6)	67.0 (7)
Iron	mg/l	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/l	0.23	0.28	0.22	0.16	0.14	0.18	0.09
Manganese	mg/l	0.18	0.16	0.18	0.17	0.28	0.14	0.21
Copper	mg/l	0.08	0.04	0.04	0.06	0.07	0.06	0.07
Boron	mg/l	<0.01	<0.01	<0.01	0.11	<0.01	<0.01	<0.01
Bulk Density	g/ml	0.272	0.367	0.31	0.31	0.264	0.426	0.328

Table 27 Leaf Tissue Analysis at First Records for each species grown in Petersfield

		Begonia at 4 weeks	Petunia at 4 weeks	Salvia at 4 weeks	Geranium at 5 weeks	Impatiens at 4 weeks	Marigold at 3 weeks
Product: Petersfield							
Nitrogen	%	3.38	N.A.	4.45	N.A.	4.17	3.82
Phosphorus	%	0.536	N.A.	0.541	N.A.	1.050	1.194
Potassium	%	2.93	N.A.	4.78	N.A.	3.72	5.30
Calcium	%	0.849	N.A.	1.721	N.A.	2.267	1.696
Magnesium	%	0.402	N.A.	0.585	N.A.	0.656	0.734
Manganese	mg/kg	155.34	N.A.	261.27	N.A.	271.08	424.20
Product: Control - Levington M2							
Nitrogen	%	4.04	N.A.	4.00	N.A.	4.04	4.16
Phosphorus	%	0.513	N.A.	0.501	N.A.	1.092	1.079
Potassium	%	3.13	N.A.	5.72	N.A.	2.80	5.10
Calcium	%	1.225	N.A.	1.455	N.A.	2.321	1.687
Magnesium	%	0.935	N.A.	1.082	N.A.	1.414	1.390
Manganese	mg/kg	153.64	N.A.	200.40	N.A.	131.68	255.78

APPENDIX VI

Table 28 **Media Analysis of Freeland Technologies at First Records for each species (water available - extractable analysis)**

		At Potting	Begonia at 4 weeks	Petunia at 4 weeks	Salvia at 4 weeks	Geranium at 5 weeks	Impatiens at 4 weeks	Marigold at 3 weeks
Product: Freeland Technologies								
pH		7.6	7.7	7.9	7.6	7.8	7.5	7.6
Conductivity uS/20°C		456.0 (3)	462.0 (3)	362.0 (2)	374.0 (2)	357.0 (2)	393.0 (2)	406.0 (3)
Nitrate (as N)	mg/l	106.0 (4)	46.0 (2)	2.0 (0)	24.0 (1)	26.0 (2)	25.0 (1)	35.0 (2)
Ammonium (as N)	mg/l	1.0 (0)	0.1 (0)	0.5 (0)	0.6 (0)	1.2 (0)	0.8 (0)	0.1 (0)
Potassium	mg/l	588.0 (6)	607.0 (6)	512.0 (6)	487.0 (6)	493.0 (6)	515.0 (6)	509.0 (6)
Calcium	mg/l	89.0	85.0	66.0	84.0	64.0	92.0	59.0
Magnesium	mg/l	14.0 (2)	12.0 (2)	10.0 (1)	15.0 (2)	11.0 (2)	18.0 (3)	11.0 (2)
Phosphorus	mg/l	25.0 (4)	27.0 (4)	22.0 (4)	26.0 (4)	26.0 (4)	27.0 (4)	21.0 (4)
Iron	mg/l	8.84	4.24	10.24	5.84	7.95	17.13	15.31
Zinc	mg/l	0.29	0.26	0.33	0.40	0.20	0.53	0.30
Manganese	mg/l	0.17	0.11	0.13	0.14	0.11	0.32	0.19
Copper	mg/l	0.21	0.11	0.12	0.13	0.12	0.13	0.13
Boron	mg/l	0.13	0.11	0.21	0.19	0.26	0.46	0.34
Bulk Density	g/ml	0.471	0.44	0.42	0.42	0.41	0.41	0.463
Product: Control - Levington M2								
pH		5.8	5.9	5.9	5.9	5.8	6.0	5.6
Conductivity uS/20°C		352.0 (2)	330.0 (2)	230.0 (1)	224.0 (1)	255.0 (1)	176.0 (1)	270.0 (1)
Nitrate (as N)	mg/l	114.0 (4)	106.0 (4)	64.0 (3)	53.0 (3)	67.0 (3)	38.0 (2)	74.0 (3)
Ammonium (as N)	mg/l	47.0 (1)	40.2 (1)	0.6 (0)	0.6 (0)	16.0 (0)	0.6 (0)	0.3 (0)
Potassium	mg/l	126.0 (3)	134.0 (3)	46.0 (1)	55.0 (2)	85.0 (2)	67.0 (2)	90.0 (2)
Calcium	mg/l	80.0	80.0	82.0	85.0	69.0	57.0	105.0
Magnesium	mg/l	83.0 (6)	64.0 (6)	75.0 (6)	76.0 (6)	65.0 (6)	50.0 (6)	94.0 (7)
Phosphorus	mg/l	89.0 (8)	82.0 (8)	48.0 (6)	55.0 (7)	66.0 (7)	45.0 (6)	67.0 (7)
Iron	mg/l	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/l	0.23	0.28	0.22	0.16	0.14	0.18	0.09
Manganese	mg/l	0.18	0.16	0.18	0.17	0.28	0.14	0.21
Copper	mg/l	0.08	0.04	0.04	0.06	0.07	0.06	0.07
Boron	mg/l	<0.01	<0.01	<0.01	0.11	<0.01	<0.01	<0.01
Bulk Density	g/ml	0.272	0.367	0.31	0.31	0.264	0.426	0.328

Table 29 **Leaf Tissue Analysis at First Records for each species grown in Freeland Technologies**

		Begonia at 4 weeks	Petunia at 4 weeks	Salvia at 4 weeks	Geranium at 5 weeks	Impatiens at 4 weeks	Marigold at 3 weeks
Product: Freeland Technologies							
Nitrogen	%	3.33	N.A.	3.48	N.A.	3.66	3.14
Phosphorus	%	0.472	N.A.	0.423	N.A.	0.712	0.496
Potassium	%	5.03	N.A.	7.17	N.A.	6.53	4.89
Calcium	%	1.167	N.A.	0.960	N.A.	2.095	1.205
Magnesium	%	0.887	N.A.	0.413	N.A.	0.480	0.451
Manganese	mg/kg	87.98	N.A.	107.50	N.A.	114.16	121.27
Product: Control - Levington M2							
Nitrogen	%	4.04	N.A.	4.00	N.A.	4.04	4.16
Phosphorus	%	0.513	N.A.	0.501	N.A.	1.092	1.079
Potassium	%	3.13	N.A.	5.72	N.A.	2.80	5.10
Calcium	%	1.225	N.A.	1.455	N.A.	2.321	1.687
Magnesium	%	0.935	N.A.	1.082	N.A.	1.414	1.390
Manganese	mg/kg	153.64	N.A.	200.40	N.A.	131.68	255.78

APPENDIX VII

Plant Growth Records - Marketing

Table 30 **Geranium** Replicate 1 (and *Replicate 2*)
(recorded 8 weeks after pricking-off)

Product	Plant Height (cm)	Rooting Score (1-3)	Plant Quality (0-2)	Foliage Score (1-3)	Fresh Weight (g)	% Dry Matter
Grodan	10.9 *(11.4)*	2.3 *(2.7)*	2.0 *(2.0)*	2.0 *(2.0)*	189.6	9.5
Wessex	-	-	-	-	-	-
SHL	10.3 *(12.0)*	2.3 *(2.9)*	2.0 *(2.0)*	2.0 *(2.0)*	172.8	9.2
Roffey	10.8 *(11.7)*	3.0 *(2.6)*	2.0 *(2.0)*	3.0 *(2.0)*	170.0	9.9
Bulrush	10.3 *(13.9)*	2.0 *(3.0)*	2.0 *(2.0)*	2.0 *(2.0)*	150.7	10.7
Melcourt	8.2 *(13.9)*	2.0 *(2.5)*	1.5 *(2.0)*	1.0 *(2.0)*	87.0	10.3
Shamrock	10.3 *(12.0)*	2.0 *(2.3)*	2.0 *(2.0)*	2.7 *(3.0)*	114.3	9.9
Petersfield	11.2 *(11.3)*	2.5 *(2.3)*	2.0 *(2.0)*	3.0 *(3.0)*	160.5	9.7
Freeland	9.5 *(9.9)*	2.6 *(2.0)*	2.0 *(2.0)*	2.0 *(2.0)*	122.2	9.6
Levington	11.4	2.0	2.0	2.0	177.7	8.9
Mean	10.3 *(10.7)*	2.3 *(2.5)*	1.9 *(2.0)*	2.2 *(2.0)*	149.4	9.7

Table 31 *Salvia* Replicate 1 (and *Replicate 2*)
(recorded 6 weeks after pricking -off)

Product	Plant Height (cm)	Rooting Score (1-3)	Plant Quality (0-2)	Foliage Score (1-3)	Fresh Weight (g)	% Dry Matter
Grodan	40.2 *(22.5)*	3.0 *(3.0)*	2.0 *(2.0)*	3.0 *(3.0)*	256.0	9.4
Wessex	- *(12.1)*	- *(2.5)*	- *(1.0)*	- *(1.9)*	-	-
SHL	32.0 *(17.9)*	3.0 *(3.0)*	2.0 *(2.0)*	3.0 *(3.0)*	273.0	7.9
Roffey	38.5 *(17.0)*	2.8 *(3.0)*	2.0 *(1.9)*	3.0 *(2.9)*	326.0	8.5
Bulrush	32.7 *(14.0)*	2.5 *(2.7)*	1.0 *(1.7)*	2.0 *(3.0)*	241.0	9.8
Melcourt	32.0 *(12.4)*	2.7 *(3.0)*	1.0 *(1.8)*	2.0 *(3.0)*	220.0	9.3
Shamrock	35.3 *(14.0)*	2.4 *(2.9)*	2.0 *(1.3)*	2.0 *(2.9)*	234.0	9.8
Petersfield	30.9 *(17.0*	2.7 *(3.0)*	2.0 *(2.0)*	3.0 *(3.0)*	292.0	8.4
Freeland	33.3 *(13.9)*	1.9 *(2.8)*	1.0 *(1.4)*	1.0 *(1.7)*	178.0	10.3
Levington	33.7	3.0	2.0	3.0	250.0	8.7
Mean	34.3 *(15.6)*	2.7 *(2.9)*	1.7 *(1.7)*	2.4 *(2.7)*	252.0	9.1

APPENDIX VII

Plant Growth Records - Marketing

Table 32 **Marigold** Replicate 1 (and *Replicate 2*)
(recorded 5 weeks after pricking-off)

Product	Plant Height (cm)	Rooting Score (1-3)	Plant Quality (0-2)	Foliage Score (1-3)	Fresh Weight (g)	% Dry Matter
Grodan	14.3 *(16.1)*	3.0 *(3.0)*	2.0 *(2.0)*	2.0 *(2.0)*	88.2	9.4
Wessex	13.7 *(13.4)*	2.9 *(2.9)*	1.0 *(1.0)*	1.0 *(1.0)*	53.7	9.3
SHL	14.7 *(13.0)*	3.0 *(3.0)*	1.9 *(2.0)*	2.0 *(3.0)*	154.2	7.7
Roffey	14.1 *(13.3)*	3.0 *(2.9)*	2.0 *(2.0)*	3.0 *(2.0)*	147.6	8.1
Bulrush	13.0 *(13.0)*	3.0 *(3.0)*	2.0 *(2.0)*	2.0 *(3.0)*	118.8	9.4
Melcourt	10.7 *(11.8)*	2.7 *(2.7)*	2.0 *(2.0)*	2.0 *(2.0)*	71.6	10.1
Shamrock	10.7 *(12.8)*	2.9 *(3.0)*	2.0 *(2.0)*	3.0 *(2.0)*	69.8	11.0
Petersfield	12.9 *(14.5)*	3.0 *(3.0)*	2.0 *(2.0)*	2.0 *(3.0)*	126.7	8.1
Freeland	11.4 *(11.5)*	3.0 *(2.9)*	1.0 *(1.0)*	2.0 *(3.0)*	62.6	9.9
Levington	13.0	3.0	2.0	2.0	117.7	8.7
Mean	12.8 *(13.3)*	2.9 *(2.9)*	1.8 *(1.8)*	2.1 *(2.3)*	101.1	9.2

Table 33 ***Petunia*** Replicate 1 (and *Replicate 2*)
(recorded 6 weeks after pricking-off)

Product	Plant Height (cm)	Rooting Score (1-3)	Plant Quality (0-2)	Foliage Score (1-3)	Fresh Weight (g)	% Dry Matter
Grodan	11.7 *(19.3)*	2.6 *(2.2)*	2.0 *(2.0)*	3.0 *(2.0)*	178.0	9.1
Wessex	-	-	-	-	-	-
SHL	13.9 *(21.2)*	1.3 *(1.0)*	2.0 *(2.0)*	2.0 *(1.0)*	201.0	8.4
Roffey	18.4 *(27.2)*	2.4 *(2.1)*	1.0 *(1.0)*	3.0 *(2.0)*	350.0	6.8
Bulrush	15.2 *(14.2)*	1.3 *(2.1)*	1.0 *(2.0)*	1.0 *(3.0)*	275.0	6.1
Melcourt	14.7 *(12.7)*	1.9 *(1.7)*	1.0 *(1.0)*	2.0 *(3.0)*	322.0	5.1
Shamrock	11.8 *(16.7)*	2.5 *(2.0)*	2.0 *(2.0)*	3.0 *(2.0)*	181.0	9.1
Petersfield	25.5 *(15.1)*	2.8 *(2.6)*	1.0 *(1.0)*	3.0 *(3.0)*	385.0	6.9
Freeland	7.9 *(9.7)*	1.9 *(2.3)*	1.5 *(1.0)*	3.0 *(2.0)*	165.0	5.8
Levington	23.2	2.0	1.0	2.0	355.0	6.7
Mean	15.8 *(17.0)*	2.1 *(2.0)*	1.4 *(1.5)*	2.4 *(2.2)*	268.0	7.1

APPENDIX VII

Plant Growth Records - Marketing

Table 34 *Begonia* Replicate 1 (and *Replicate 2*)
(recorded 6 weeks after pricking-out)

Product	Plant Height (cm)	Rooting Score (1-3)	Plant Quality (0-2)	Foliage Score (1-3)	Fresh Weight (g)	% Dry Matter
Grodan	8.7 *(17.0)*	3.0 *(3.0)*	2.0 *(2.0)*	2.0 *(1.0)*	278.0	3.1
Wessex	-	-	-	-	-	-
SHL	7.2 *(8.8)*	2.6 *(2.7)*	1.8 *(2.0)*	1.8 *(2.3)*	229.3	3.6
Roffey	7.2 *(12.0)*	2.8 *(2.7)*	2.0 *(2.0)*	1.8 *(1.5)*	251.3	3.8
Bulrush	5.1 *(8.0)*	1.0 *(1.8)*	2.0 *(2.0)*	2.1 *(3.0)*	113.3	4.8
Melcourt	5.1 *(6.2)*	1.4 *(1.0)*	1.6 *(1.8)*	2.6 *(1.8)*	133.5	4.5
Shamrock	7.9 *(6.9)*	3.0 *(1.2)*	2.0 *(1.5)*	2.0 *(1.7)*	241.4	3.7
Petersfield	17.9 *(18.2)*	3.0 *(3.0)*	2.0 *(2.9)*	2.0 *(1.0)*	378.0	3.2
Freeland	7.5 *(5.8)*	2.8 *(1.9)*	1.2 *(1.3)*	1.3 *(1.3)*	214.7	3.9
Levington	7.0	2.3	2.0	2.8	117.8	4.3
Mean	8.2 *(10.4)*	2.4 *(2.2)*	1.8 *(1.9)*	2.0 *(1.7)*	217.5	3.9

Table 35 *Impatiens* Replicate 1 (and *Replicate 2*)
(recorded 6 weeks after pricking-off)

Product	Plant Height (cm)	Rooting Score (1-3)	Plant Quality (0-2)	Foliage Score (1-3)	Fresh Weight (g)	% Dry Matter
Grodan	18.6 *(13.0)*	2.5 *(3.0)*	1.5 *(1.0)*	2.0 *(2.0)*	258.0	5.1
Wessex	- *(4.6)*	- *(1.6)*	- *(1.0)*	- *(1.0)*	*(40.3)*	*(5.7)*
SHL	17.6 *(7.4)*	2.5 *(2.4)*	2.0 *(2.0)*	3.0 *(2.0)*	281.0	4.2
Roffey	14.5 *(5.6)*	2.4 *(2.8)*	2.0 *(2.0)*	2.0 *(2.5)*	217.0	5.6
Bulrush	9.9 *(5.6)*	2.4 *(2.4)*	2.0 *(2.0)*	3.0 *(2.9)*	156.0	6.4
Melcourt	7.4 *(5.5)*	1.2 *(1.2)*	1.0 *(1.0)*	1.0 *(1.7)*	59.0	7.3
Shamrock	10.3 *(6.8)*	2.0 *(2.5)*	2.0 *(2.0)*	2.0 *(2.7)*	178.0	6.1
Petersfield	18.1 *(10.4)*	2.8 *(3.0)*	2.0 *(2.0)*	3.0 *(3.0)*	278.0	5.2
Freeland	8.0 *(5.5)*	1.2 *(1.6)*	1.0 *(0.7)*	1.0 *(1.6)*	72.0	6.4
Levington	10.7	1.8	2.0	2.0	186.0	6.0
Mean	12.8 *(7.1)*	2.1 *(2.3)*	1.7 *(1.5)*	2.1 *(2.1)*	172.5	5.8

COMMERCIAL - IN CONFIDENCE

APPENDIX VIII

Plate 11 *Petunia* : Treatment Comparison at Marketing
(control - Levington M2, on left)

Rockwool

SHL

Roffey

APPENDIX VIII

Plate 12 *Petunia* : Treatment Comparison at Marketing
(control - Levington M2, on left)

Bulrush
(control not shown)

Melcourt

Shamrock

APPENDIX VIII

Plate 13 *Petunia* : Treatment Comparison at Marketing
(control - Levington M2, on left)

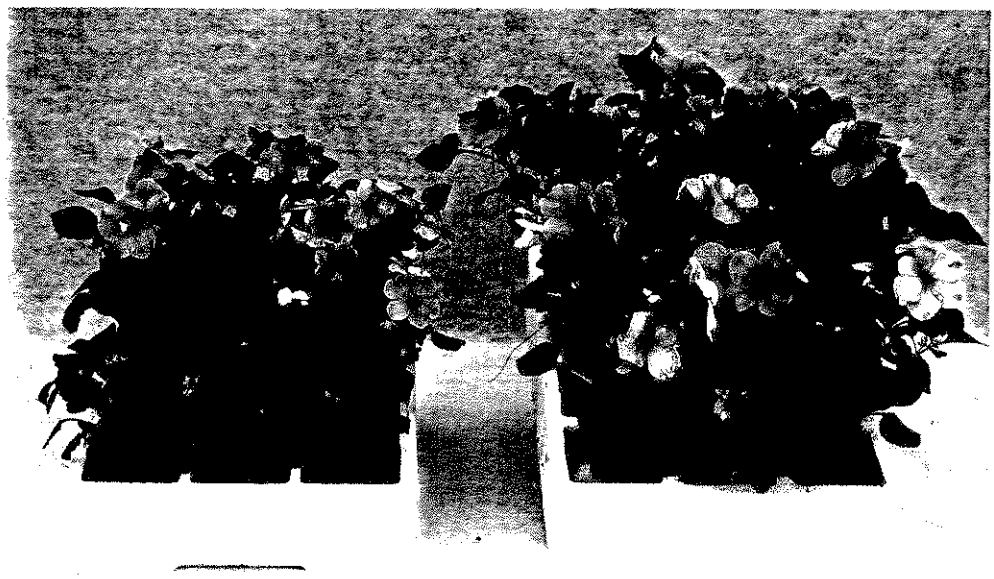
Petersfield

Freeland

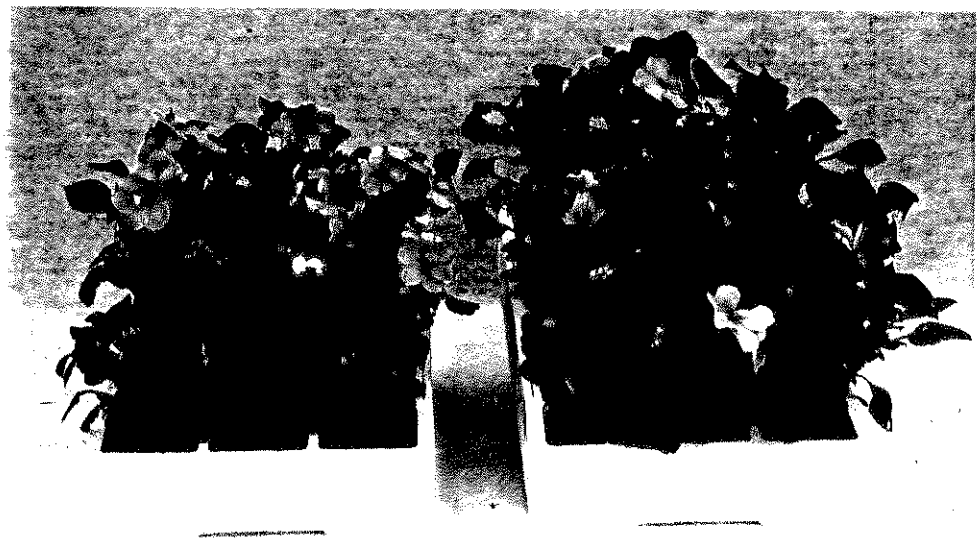
APPENDIX VIII

Plate 14 *Impatiens* : Treatment Comparison at Marketing
(control - Levington M2, on left)

Rockwool



SHL

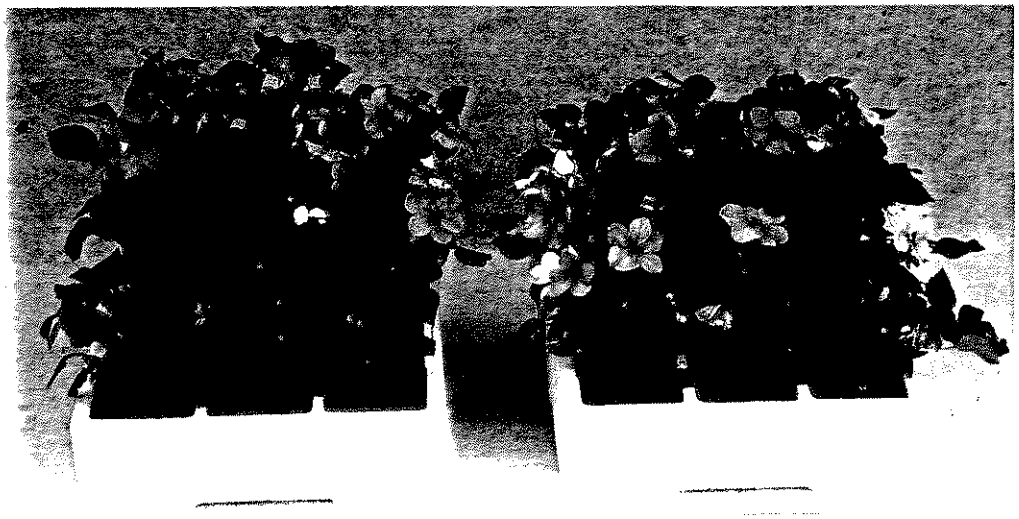


Roffey

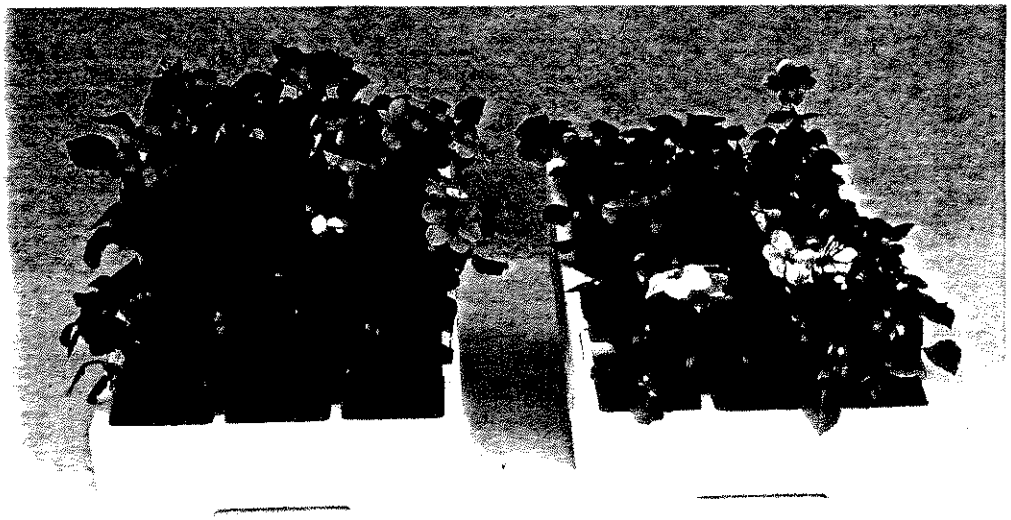
COMMERCIAL - IN CONFIDENCE

APPENDIX VIII

Plate 15 *Impatiens* : Treatment Comparison at Marketing
(control - Levington M2, on left)



Bulrush



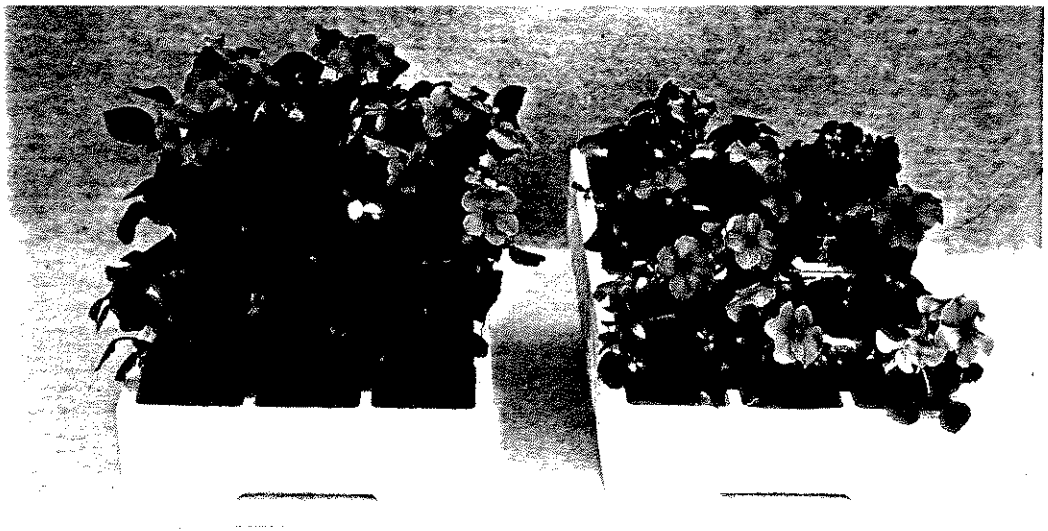
Melcourt

Shamrock

APPENDIX VIII

Plate 16 *Impatiens* : Treatment Comparison at Marketing
(control - Levington M2, on left)

Petersfield



Freeland

APPENDIX IX

Table 36 Media Analysis of Grodana at Marketing for each species (water available - extractable analysis)

		At Potting	Begonia at 6 weeks	Petunia at 6 weeks	Salvia at 6 weeks	Geranium at 8 weeks	Impatiens at 6 weeks	Marigold at 5 weeks
Product: Grodania								
pH		8.3	7.8	8.5	7.6	7.2	7.7	8.6
Conductivity uS/20°C		88.0 (0)	167.0 (1)	63.0 (0)	144.0 (0)	100.0 (0)	41.0 (0)	109.0 (0)
Nitrate (as N)	mg/l	15.0 (1)	62.0 (3)	1.0 (0)	<0.1 (0)	32.0 (2)	3.0 (0)	25.0 (1)
Ammonium (as N)	mg/l	5.9 (0)	0.3 (0)	0.1 (0)	0.3 (0)	0.3 (0)	0.1 (0)	0.3 (0)
Potassium	mg/l	16.0 (0)	104.0 (3)	18.0 (0)	143.0 (3)	34.0 (1)	37.0 (1)	56.0 (2)
Calcium	mg/l	47.0	79.0	50.0	57.0	59.0	11.0	65.0
Magnesium	mg/l	7.0 (1)	11.0 (2)	5.0 (0)	12.0 (2)	14.0 (2)	1.0 (0)	9.0 (1)
Phosphorus	mg/l	1.0 (0)	11.0 (3)	7.0 (1)	12.0 (3)	7.0 (1)	2.0 (0)	9.0 (2)
Iron	mg/l	0.17	4.17	2.09	8.93	1.17	<0.01	11.71
Zinc	mg/l	0.01	<0.01	0.05	0.06	0.25	0.04	0.24
Manganese	mg/l	0.05	0.03	0.05	0.42	0.06	0.01	0.06
Copper	mg/l	0.01	0.01	0.02	0.05	0.02	0.01	0.03
Boron	mg/l	0.07	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Bulk Density	g/ml	0.130	0.551	0.14	0.560	0.194	0.18	0.474
Product: Control - Levington M2								
pH		5.8	5.6	6.1	6.0	5.8	5.8	5.7
Conductivity uS/20°C		353.0 (2)	404.0 (3)	133.0 (0)	162.0 (1)	245.0 (1)	212.0 (1)	265.0 (1)
Nitrate (as N)	mg/l	114.0 (4)	154.0 (5)	37.0 (2)	36.0 (2)	85.0 (4)	40.0 (2)	72.0 (3)
Ammonium (as N)	mg/l	47.0 (1)	0.3 (0)	0.3 (0)	1.1 (0)	0.3 (0)	0.1 (0)	0.7 (0)
Potassium	mg/l	126.0 (3)	154.0 (3)	28.0 (1)	80.0 (2)	82.0 (2)	77.0 (2)	74.0 (2)
Calcium	mg/l	80.0	126.0	49.0	53.0	87.0	69.0	101.0
Magnesium	mg/l	83.0 (6)	130.0 (7)	43.0 (5)	49.0 (5)	90.0 (7)	65.0 (6)	96.0 (7)
Phosphorus	mg/l	89.0 (8)	90.0 (8)	45.0 (6)	55.0 (7)	60.0 (7)	50.0 (6)	64.0 (7)
Iron	mg/l	0.06	<0.01	<0.01	<0.01	<0.01	0.35	<0.01
Zinc	mg/l	0.23	0.16	0.08	1.11	0.20	0.34	1.66
Manganese	mg/l	0.18	0.23	0.07	0.07	0.14	0.16	0.20
Copper	mg/l	0.08	0.05	0.06	0.04	0.06	0.04	0.05
Boron	mg/l	<0.01	<0.01	0.04	0.21	<0.01	<0.01	0.10
Bulk Density	g/ml	0.272	0.257	0.471	0.438	0.293	0.22	0.337

Table 37 Leaf Tissue Analysis at Marketing for each species grown in Grodana

		Begonia at 6 weeks	Petunia at 6 weeks	Salvia at 6 weeks	Geranium at 8 weeks	Impatiens at 6 weeks	Marigold at 5 weeks
Product: Grodania							
Nitrogen	%	3.97	3.71	4.24	3.71	4.80	3.67
Phosphorus	%	0.611	0.506	0.599	0.500	1.158	0.696
Potassium	%	4.32	3.76	4.72	4.11	4.31	4.36
Calcium	%	1.741	2.005	2.147	1.496	3.255	2.470
Magnesium	%	0.733	0.657	0.517	0.474	0.560	0.631
Manganese	mg/kg	61.62	99.92	118.31	37.91	117.41	142.88
Product: Control - Levington M2							
Nitrogen	%	3.20	4.14	4.25	3.82	4.72	4.95
Phosphorus	%	0.813	1.112	0.622	0.801	1.088	1.104
Potassium	%	6.00	6.70	4.47	3.93	3.00	5.79
Calcium	%	0.966	1.323	1.533	1.435	2.484	1.746
Magnesium	%	0.564	0.856	1.043	0.766	1.725	1.358
Manganese	mg/kg	86.48	138.10	218.13	130.31	216.88	324.49

APPENDIX IX

Table 38 Media Analysis of Wessex at Marketing for each species (water available - extractable analysis)

		At Potting	Begonia at 6 weeks	Petunia at 6 weeks	Salvia at 6 weeks	Geranium at 8 weeks	Impatiens at 6 weeks	Marigold at 5 weeks
Product: Wessex								
pH		6.2	N.A.	N.A.	6.6	N.A.	6.7	7.3
Conductivity uS/20°C		194.0 (1)	N.A.	N.A.	155.0 (1)	N.A.	158.0 (1)	131.0 (0)
Nitrate (as N)	mg/l	1.0 (0)	N.A.	N.A.	15.0 (1)	N.A.	32.0 (2)	7.0 (0)
Ammonium (as N)	mg/l	0.6 (0)	N.A.	N.A.	0.9 (0)	N.A.	0.8 (0)	<0.1 (0)
Potassium	mg/l	188.0 (4)	N.A.	N.A.	163.0 (3)	N.A.	169.0 (3)	126.0 (3)
Calcium	mg/l	9.0	N.A.	N.A.	10.0	N.A.	8.0	8.0
Magnesium	mg/l	1.0 (0)	N.A.	N.A.	2.0 (0)	N.A.	1.0 (0)	1.0 (0)
Phosphorus	mg/l	11.0 (3)	N.A.	N.A.	21.0 (4)	N.A.	13.0 (3)	13.0 (3)
Iron	mg/l	0.46	N.A.	N.A.	0.24	N.A.	0.45	0.39
Zinc	mg/l	0.18	N.A.	N.A.	0.10	N.A.	0.11	0.05
Manganese	mg/l	0.02	N.A.	N.A.	0.01	N.A.	0.01	0.01
Copper	mg/l	0.04	N.A.	N.A.	0.02	N.A.	0.02	0.03
Boron	mg/l	0.18	N.A.	N.A.	<0.01	N.A.	0.22	<0.01
Bulk Density	g/ml	0.248	N.A.	N.A.	0.298	N.A.	0.267	0.275
Product: Control - Levington M2								
pH		5.8	5.6	6.1	6.0	5.8	5.8	5.7
Conductivity uS/20°C		353.0 (2)	404.0 (3)	133.0 (0)	162.0 (1)	245.0 (1)	212.0 (1)	265.0 (1)
Nitrate (as N)	mg/l	114.0 (4)	154.0 (5)	37.0 (2)	36.0 (2)	85.0 (4)	40.0 (2)	72.0 (3)
Ammonium (as N)	mg/l	47.0 (1)	0.3 (0)	0.3 (0)	1.1 (0)	0.3 (0)	0.1 (0)	0.7 (0)
Potassium	mg/l	126.0 (3)	154.0 (3)	28.0 (1)	80.0 (2)	82.0 (2)	77.0 (2)	74.0 (2)
Calcium	mg/l	80.0	126.0	49.0	53.0	87.0	69.0	101.0
Magnesium	mg/l	83.0 (6)	130.0 (7)	43.0 (5)	49.0 (5)	90.0 (7)	65.0 (6)	96.0 (7)
Phosphorus	mg/l	89.0 (8)	90.0 (8)	45.0 (6)	55.0 (7)	60.0 (7)	50.0 (6)	64.0 (7)
Iron	mg/l	0.06	<0.01	<0.01	<0.01	<0.01	0.35	<0.01
Zinc	mg/l	0.23	0.16	0.08	1.11	0.20	0.34	1.66
Manganese	mg/l	0.18	0.23	0.07	0.07	0.14	0.16	0.20
Copper	mg/l	0.08	0.05	0.06	0.04	0.06	0.04	0.05
Boron	mg/l	<0.01	<0.01	0.04	0.21	<0.01	<0.01	0.10
Bulk Density	g/ml	0.272	0.257	0.471	0.438	0.293	0.22	0.337

Table 39 Leaf Tissue Analysis at Marketing for each species grown in Wessex

		Begonia at 6 weeks	Petunia at 6 weeks	Salvia at 6 weeks	Geranium at 8 weeks	Impatiens at 6 weeks	Marigold at 5 weeks
Product: Wessex							
Nitrogen	%	N.A.	N.A.	2.47	N.A.	4.17	4.36
Phosphorus	%	N.A.	N.A.	0.528	N.A.	0.969	0.966
Potassium	%	N.A.	N.A.	6.97	N.A.	5.73	5.67
Calcium	%	N.A.	N.A.	0.980	N.A.	1.514	1.330
Magnesium	%	N.A.	N.A.	0.463	N.A.	0.504	0.634
Manganese	mg/kg	N.A.	N.A.	41.73	N.A.	69.10	88.45
Product: Control - Levington M2							
Nitrogen	%	3.20	4.14	4.25	3.82	4.72	4.95
Phosphorus	%	0.813	1.112	0.622	0.801	1.088	1.104
Potassium	%	6.00	6.70	4.47	3.93	3.00	5.79
Calcium	%	0.966	1.323	1.533	1.435	2.484	1.746
Magnesium	%	0.564	0.856	1.043	0.766	1.725	1.358
Manganese	mg/kg	86.48	138.10	218.13	130.31	216.88	324.49

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Table 40 Media Analysis of SHL at Marketing for each species (water available - extractable analysis)

		At Potting	Begonia at 6 weeks	Petunia at 6 weeks	Salvia at 6 weeks	Geranium at 8 weeks	Impatiens at 6 weeks	Marigold at 5 weeks
Product: SHL								
pH		6.5	6.0	6.4	6.4	6.1	7.0	6.7
Conductivity uS/20°C		440.0 (3)	357.0 (2)	96.0 (0)	240.0 (1)	279.0 (1)	109.0 (0)	230.0 (1)
Nitrate (as N)	mg/l	102.0 (4)	96.0 (4)	1.0 (0)	<0.0 (0)	61.0 (3)	2.0 (0)	6.0 (0)
Ammonium (as N)	mg/l	70.0 (2)	0.3 (0)	<0.1 (0)	2.1 (0)	0.3 (0)	0.1 (0)	0.3 (0)
Potassium	mg/l	410.0 (6)	344.0 (5)	94.0 (2)	278.0 (5)	260.0 (5)	128.0 (3)	193.0 (4)
Calcium	mg/l	12.0	33.0	7.0	17.0	26.0	5.0	12.0
Magnesium	mg/l	8.0 (1)	28.0 (4)	2.0 (0)	13.0 (2)	23.0 (3)	2.0 (0)	5.0 (1)
Phosphorus	mg/l	74.0 (7)	52.0 (6)	16.0 (3)	57.0 (7)	39.0 (5)	13.0 (3)	34.0 (5)
Iron	mg/l	1.75	1.54	0.55	2.21	1.88	1.01	1.22
Zinc	mg/l	3.09	1.61	1.23	2.25	1.68	1.43	3.05
Manganese	mg/l	1.18	0.12	0.20	0.84	0.17	0.25	0.49
Copper	mg/l	1.71	0.68	0.45	1.25	0.58	0.61	1.11
Boron	mg/l	0.33	0.38	0.08	0.33	0.24	0.01	0.57
Bulk Density	g/ml	0.297	0.285	0.27	0.224	0.306	0.26	0.295
Product: Control - Levington M2								
pH		5.8	5.6	6.1	6.0	5.8	5.8	5.7
Conductivity uS/20°C		353.0 (2)	404.0 (3)	133.0 (0)	162.0 (1)	245.0 (1)	212.0 (1)	265.0 (1)
Nitrate (as N)	mg/l	114.0 (4)	154.0 (5)	37.0 (2)	36.0 (2)	85.0 (4)	40.0 (2)	72.0 (3)
Ammonium (as N)	mg/l	47.0 (1)	0.3 (0)	0.3 (0)	1.1 (0)	0.3 (0)	0.1 (0)	0.7 (0)
Potassium	mg/l	126.0 (3)	154.0 (3)	28.0 (1)	80.0 (2)	82.0 (2)	77.0 (2)	74.0 (2)
Calcium	mg/l	80.0	126.0	49.0	53.0	87.0	69.0	101.0
Magnesium	mg/l	83.0 (6)	130.0 (7)	43.0 (5)	49.0 (5)	90.0 (7)	65.0 (6)	96.0 (7)
Phosphorus	mg/l	89.0 (8)	90.0 (8)	45.0 (6)	55.0 (7)	60.0 (7)	50.0 (6)	64.0 (7)
Iron	mg/l	0.06	<0.01	<0.01	<0.01	<0.01	0.35	<0.01
Zinc	mg/l	0.23	0.16	0.08	1.11	0.20	0.34	1.66
Manganese	mg/l	0.18	0.23	0.07	0.07	0.14	0.16	0.20
Copper	mg/l	0.08	0.05	0.06	0.04	0.06	0.04	0.05
Boron	mg/l	<0.01	<0.01	0.04	0.21	<0.01	<0.01	0.10
Bulk Density	g/ml	0.272	0.257	0.471	0.438	0.293	0.22	0.337

Table 41 Leaf Tissue Analysis at Marketing for each species grown in SHL

		Begonia at 6 weeks	Petunia at 6 weeks	Salvia at 6 weeks	Geranium at 8 weeks	Impatiens at 6 weeks	Marigold at 5 weeks
Product: SHL							
Nitrogen	%	4.08	3.28	3.66	4.48	4.42	4.96
Phosphorus	%	0.567	0.648	0.674	0.776	1.325	1.221
Potassium	%	4.45	5.41	5.58	5.26	6.58	6.96
Calcium	%	0.676	0.533	0.745	0.694	1.318	1.044
Magnesium	%	0.641	0.371	0.492	0.407	0.754	0.715
Manganese	mg/kg	145.05	88.01	229.08	196.14	221.23	258.68
Product: Control - Levington M2							
Nitrogen	%	3.20	4.14	4.25	3.82	4.72	4.95
Phosphorus	%	0.813	1.112	0.622	0.801	1.088	1.104
Potassium	%	6.00	6.70	4.47	3.93	3.00	5.79
Calcium	%	0.966	1.323	1.533	1.435	2.484	1.746
Magnesium	%	0.564	0.856	1.043	0.766	1.725	1.358
Manganese	mg/kg	86.48	138.10	218.13	130.31	216.88	324.49

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Table 42 Media Analysis of Roffey at Marketing for each species (water available - extractable analysis)

		At Potting	Begonia at 6 weeks	Petunia at 6 weeks	Salvia at 6 weeks	Geranium at 8 weeks	Impatiens at 6 weeks	Marigold at 5 weeks
Product: Roffey								
pH		5.5	5.5	6.2	5.6	5.6	5.5	6.7
Conductivity uS/20°C		414.0 (3)	378.0 (2)	130.0 (0)	156.0 (1)	273.0 (1)	317.0 (2)	251.0 (1)
Nitrate (as N)	mg/l	202.0 (6)	173.0 (5)	45.0 (2)	35.0 (2)	127.0 (4)	128.0 (4)	69.0 (3)
Ammonium (as N)	mg/l	40.0 (1)	0.6 (0)	0.1 (0)	0.7 (0)	0.7 (0)	0.1 (0)	0.3 (0)
Potassium	mg/l	251.0 (5)	217.0 (4)	78.0 (2)	115.0 (3)	140.0 (3)	214.0 (4)	92.0 (2)
Calcium	mg/l	55.0	84.0	31.0	32.0	67.0	67.0	56.0
Magnesium	mg/l	59.0 (6)	69.0 (6)	21.0 (3)	23.0 (3)	59.0 (6)	54.0 (6)	48.0 (5)
Phosphorus	mg/l	70.0 (7)	55.0 (7)	38.0 (5)	45.0 (6)	41.0 (6)	57.0 (7)	47.0 (6)
Iron	mg/l	1.44	1.70	0.62	1.01	0.75	1.35	1.09
Zinc	mg/l	0.59	1.49	0.45	0.23	2.23	0.49	0.42
Manganese	mg/l	0.53	0.48	0.05	0.08	0.24	0.33	0.11
Copper	mg/l	0.12	0.05	0.04	0.06	0.04	0.07	0.03
Boron	mg/l	<0.01	0.27	<0.01	0.10	0.34	0.01	0.17
Bulk Density	g/ml	0.281	0.242	0.48	0.264	0.295	0.25	0.282
Product: Control - Levington M2								
pH		5.8	5.6	6.1	6.0	5.8	5.8	5.7
Conductivity uS/20°C		353.0 (2)	404.0 (3)	133.0 (0)	162.0 (1)	245.0 (1)	212.0 (1)	265.0 (1)
Nitrate (as N)	mg/l	114.0 (4)	154.0 (5)	37.0 (2)	36.0 (2)	85.0 (4)	40.0 (2)	72.0 (3)
Ammonium (as N)	mg/l	47.0 (1)	0.3 (0)	0.3 (0)	1.1 (0)	0.3 (0)	0.1 (0)	0.7 (0)
Potassium	mg/l	126.0 (3)	154.0 (3)	28.0 (1)	80.0 (2)	82.0 (2)	77.0 (2)	74.0 (2)
Calcium	mg/l	80.0	126.0	49.0	53.0	87.0	69.0	101.0
Magnesium	mg/l	83.0 (6)	130.0 (7)	43.0 (5)	49.0 (5)	90.0 (7)	65.0 (6)	96.0 (7)
Phosphorus	mg/l	89.0 (8)	90.0 (8)	45.0 (6)	55.0 (7)	60.0 (7)	50.0 (6)	64.0 (7)
Iron	mg/l	0.06	<0.01	<0.01	<0.01	<0.01	0.35	<0.01
Zinc	mg/l	0.23	0.16	0.08	1.11	0.20	0.34	1.66
Manganese	mg/l	0.18	0.23	0.07	0.07	0.14	0.16	0.20
Copper	mg/l	0.08	0.05	0.06	0.04	0.06	0.04	0.05
Boron	mg/l	<0.01	<0.01	0.04	0.21	<0.01	<0.01	0.10
Bulk Density	g/ml	0.272	0.257	0.471	0.438	0.293	0.22	0.337

Table 43 Leaf Tissue Analysis at Marketing for each species grown in Roffey

		Begonia at 6 weeks	Petunia at 6 weeks	Salvia at 6 weeks	Geranium at 8 weeks	Impatiens at 6 weeks	Marigold at 5 weeks
Product: Roffey							
Nitrogen	%	4.61	3.73	4.57	3.68	4.60	4.35
Phosphorus	%	0.554	0.603	0.627	0.716	1.193	1.108
Potassium	%	4.20	5.75	4.38	4.40	3.98	5.94
Calcium	%	1.028	1.004	1.694	1.330	2.383	1.572
Magnesium	%	1.141	0.763	0.866	0.673	1.417	1.215
Manganese	mg/kg	124.26	93.15	274.43	164.72	247.41	339.81
Product: Control - Levington M2							
Nitrogen	%	3.20	4.14	4.25	3.82	4.72	4.95
Phosphorus	%	0.813	1.112	0.622	0.801	1.088	1.104
Potassium	%	6.00	6.70	4.47	3.93	3.00	5.79
Calcium	%	0.966	1.323	1.533	1.435	2.484	1.746
Magnesium	%	0.564	0.856	1.043	0.766	1.725	1.358
Manganese	mg/kg	86.48	138.10	218.13	130.31	216.88	324.49

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Table 44 Media Analysis of Bulrush at Marketing for each species (water available - extractable analysis)

		At Potting	Begonia at 6 weeks	Petunia at 6 weeks	Salvia at 6 weeks	Geranium at 8 weeks	Impatiens at 6 weeks	Marigold at 5 weeks
Product: Bulrush								
pH		6.9	7.1	7.2	7.2	7.0	7.1	7.4
Conductivity uS/20°C		668.0 (5)	429.0 (3)	312.0 (2)	271.0 (1)	521.0 (4)	419.0 (3)	299.0 (1)
Nitrate (as N)	mg/l	177.0 (5)	112.0 (4)	63.0 (3)	41.0 (2)	134.0 (5)	48.0 (2)	51.0 (3)
(Ammonium (as N)	mg/l	16.0 (0)	1.3 (0)	0.3 (0)	0.3 (0)	3.7 (0)	0.9 (0)	0.3 (0)
Potassium	mg/l	71.0 (2)	53.0 (2)	44.0 (1)	1728.0 (9)	60.0 (2)	53.0 (2)	30.0 (1)
Calcium	mg/l	385.0	206.0	149.0	149.0	283.0	229.0	154.0
Magnesium	mg/l	231.0 (9)	142.0 (7)	97.0 (7)	95.0 (7)	192.0 (8)	114.0 (7)	101.0 (7)
Phosphorus	mg/l	11.0 (2)	6.0 (1)	6.0 (1)	6.0 (1)	9.0 (2)	7.0 (2)	4.0 (0)
Iron	mg/l	0.90	<0.01	0.22	0.06	<0.01	1.39	0.81
Zinc	mg/l	0.63	0.26	0.25	0.26	0.61	0.52	0.33
Manganese	mg/l	4.86	2.37	1.23	1.22	3.15	1.15	2.10
Copper	mg/l	0.31	0.11	0.09	0.10	0.15	0.13	0.09
Boron	mg/l	<0.01	<0.01	0.23	<0.01	0.35	<0.01	0.23
Bulk Density	g/ml	0.653	0.367	0.618	0.663	0.647	0.62	0.689
Product: Control - Levington M2								
pH		5.8	5.6	6.1	6.0	5.8	5.8	5.7
Conductivity uS/20°C		353.0 (2)	404.0 (3)	133.0 (0)	162.0 (1)	245.0 (1)	212.0 (1)	265.0 (1)
Nitrate (as N)	mg/l	114.0 (4)	154.0 (5)	37.0 (2)	36.0 (2)	85.0 (4)	40.0 (2)	72.0 (3)
Ammonium (as N)	mg/l	47.0 (1)	0.3 (0)	0.3 (0)	1.1 (0)	0.3 (0)	0.1 (0)	0.7 (0)
Potassium	mg/l	126.0 (3)	154.0 (3)	28.0 (1)	80.0 (2)	82.0 (2)	77.0 (2)	74.0 (2)
Calcium	mg/l	80.0	126.0	49.0	53.0	87.0	69.0	101.0
Magnesium	mg/l	83.0 (6)	130.0 (7)	43.0 (5)	49.0 (5)	90.0 (7)	65.0 (6)	96.0 (7)
Phosphorus	mg/l	89.0 (8)	90.0 (8)	45.0 (6)	55.0 (7)	60.0 (7)	50.0 (6)	64.0 (7)
Iron	mg/l	0.06	<0.01	<0.01	<0.01	<0.01	0.35	<0.01
Zinc	mg/l	0.23	0.16	0.08	1.11	0.20	0.34	1.66
Manganese	mg/l	0.18	0.23	0.07	0.07	0.14	0.16	0.20
Copper	mg/l	0.08	0.05	0.06	0.04	0.06	0.04	0.05
Boron	mg/l	<0.01	<0.01	0.04	0.21	<0.01	<0.01	0.10
Bulk Density	g/ml	0.272	0.257	0.471	0.438	0.293	0.22	0.337

Table 45 Leaf Tissue Analysis at Marketing for each species grown in Bulrush

		Begonia at 6 weeks	Petunia at 6 weeks	Salvia at 6 weeks	Geranium at 8 weeks	Impatiens at 6 weeks	Marigold at 5 weeks
Product: Bulrush							
Nitrogen	%	3.71	3.54	3.90	4.25	3.73	4.09
Phosphorus	%	0.493	0.620	0.533	0.504	0.534	0.745
Potassium	%	2.98	6.45	4.50	3.73	2.54	4.34
Calcium	%	1.596	1.880	1.901	1.903	2.948	1.884
Magnesium	%	1.386	1.043	1.011	0.848	1.024	1.116
Manganese	mg/kg	368.23	380.05	480.67	621.86	217.93	676.11
Product: Control - Levington M2							
Nitrogen	%	3.20	4.14	4.25	3.82	4.72	4.95
Phosphorus	%	0.813	1.112	0.622	0.801	1.088	1.104
Potassium	%	6.00	6.70	4.47	3.93	3.00	5.79
Calcium	%	0.966	1.323	1.533	1.435	2.484	1.746
Magnesium	%	0.564	0.856	1.043	0.766	1.725	1.358
Manganese	mg/kg	86.48	138.10	218.13	130.31	216.88	324.49

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Table 46 Media Analysis of Melcourt at Marketing for each species (water available - extractable analysis)

		At Potting	Begonia at 6 weeks	Petunia at 6 weeks	Salvia at 6 weeks	Geranium at 8 weeks	Impatiens at 6 weeks	Marigold at 5 weeks
Product: Melcourt								
pH		5.7	5.9	6.2	6.1	6.0	5.9	6.1
Conductivity uS/20°C		590.0 (4)	480.0 (3)	276.0 (1)	287.0 (1)	494.0 (3)	442.0 (3)	398.0 (2)
Nitrate (as N)	mg/l	192.0 (5)	179.0 (5)	63.0 (3)	19.0 (1)	152.0 (5)	136.0 (5)	119.0 (4)
Ammonium (as N)	mg/l	34.0 (1)	1.4 (0)	0.8 (0)	1.8 (0)	35.1 (1)	18.1 (0)	22.3 (1)
Potassium	mg/l	451.0 (6)	422.0 (6)	197.0 (4)	211.0 (4)	384.0 (1)	404.0 (6)	322.0 (5)
Calcium	mg/l	252.0	187.0	138.0	143.0	192.0	164.0	171.0
Magnesium	mg/l	55.0 (6)	48.0 (5)	35.0 (4)	34.0 (4)	59.0 (6)	34.0 (4)	43.0 (5)
Phosphorus	mg/l	108.0 (9)	81.0 (8)	66.0 (7)	89.0 (8)	93.0 (8)	84.0 (8)	80.0 (8)
Iron	mg/l	<0.01	0.07	0.11	0.05	<0.01	0.57	0.55
Zinc	mg/l	0.47	0.34	0.16	0.49	0.32	0.29	0.35
Manganese	mg/l	7.88	3.42	0.31	1.93	2.30	3.66	3.00
Copper	mg/l	0.12	0.07	0.03	0.05	0.04	0.04	0.03
Boron	mg/l	<0.01	0.03	<0.01	<0.01	0.02	<0.01	<0.01
Bulk Density	g/ml	0.369	0.391	0.437	0.362	0.400	0.39	0.400
Product: Control - Levington M2								
pH		5.8	5.6	6.1	6.0	5.8	5.8	5.7
Conductivity uS/20°C		353.0 (2)	404.0 (3)	133.0 (0)	162.0 (1)	245.0 (1)	212.0 (1)	265.0 (1)
Nitrate (as N)	mg/l	114.0 (4)	154.0 (5)	37.0 (2)	36.0 (2)	85.0 (4)	40.0 (2)	72.0 (3)
Ammonium (as N)	mg/l	47.0 (1)	0.3 (0)	0.3 (0)	1.1 (0)	0.3 (0)	0.1 (0)	0.7 (0)
Potassium	mg/l	126.0 (3)	154.0 (3)	28.0 (1)	80.0 (2)	82.0 (2)	77.0 (2)	74.0 (2)
Calcium	mg/l	80.0	126.0	49.0	53.0	87.0	69.0	101.0
Magnesium	mg/l	83.0 (6)	130.0 (7)	43.0 (5)	49.0 (5)	90.0 (7)	65.0 (6)	96.0 (7)
Phosphorus	mg/l	89.0 (8)	90.0 (8)	45.0 (6)	55.0 (7)	60.0 (7)	50.0 (6)	64.0 (7)
Iron	mg/l	0.06	<0.01	<0.01	<0.01	<0.01	0.35	<0.01
Zinc	mg/l	0.23	0.16	0.08	1.11	0.20	0.34	1.66
Manganese	mg/l	0.18	0.23	0.07	0.07	0.14	0.16	0.20
Copper	mg/l	0.08	0.05	0.06	0.04	0.06	0.04	0.05
Boron	mg/l	<0.01	<0.01	0.04	0.21	<0.01	<0.01	0.10
Bulk Density	g/ml	0.272	0.257	0.471	0.438	0.293	0.22	0.337

Table 47 Leaf Tissue Analysis at Marketing for each species grown in Melcourt

		Begonia at 6 weeks	Petunia at 6 weeks	Salvia at 6 weeks	Geranium at 8 weeks	Impatiens at 6 weeks	Marigold at 5 weeks
Product: Melcourt							
Nitrogen	%	3.94	3.81	4.49	3.45	4.05	4.81
Phosphorus	%	0.551	1.004	0.659	0.536	0.882	0.768
Potassium	%	4.57	8.18	6.57	4.37	4.74	4.80
Calcium	%	1.534	1.910	1.579	1.427	2.860	1.810
Magnesium	%	0.737	0.440	0.493	0.392	0.596	0.625
Manganese	mg/kg	516.78	655.11	752.47	678.21	702.44	1311.58
Product: Control - Levington M2							
Nitrogen	%	3.20	4.14	4.25	3.82	4.72	4.95
Phosphorus	%	0.813	1.112	0.622	0.801	1.088	1.104
Potassium	%	6.00	6.70	4.47	3.93	3.00	5.79
Calcium	%	0.966	1.323	1.533	1.435	2.484	1.746
Magnesium	%	0.564	0.856	1.043	0.766	1.725	1.358
Manganese	mg/kg	86.48	138.10	218.13	130.31	216.88	324.49

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Table 48 Media Analysis of Shamrock at Marketing for each species (water available - extractable analysis)

		At Potting	Begonia at 6 weeks	Petunia at 6 weeks	Salvia at 6 weeks	Geranium at 8 weeks	Impatiens at 6 weeks	Marigold at 5 weeks
Product: Shamrock								
pH		5.5	5.9	6.2	6.4	5.9	6.3	6.0
Conductivity uS/20°C		435.0 (3)	378.0 (2)	132.0 (0)	150.0 (0)	272.0 (1)	159.0 (1)	288.0 (1)
Nitrate (as N)	mg/l	253.0 (6)	196.0 (5)	51.0 (3)	39.0 (2)	142.0 (5)	59.0 (3)	149.0 (5)
Ammonium (as N)	mg/l	0.9 (0)	0.3 (0)	0.1 (0)	0.8 (0)	0.3 (0)	0.1 (0)	0.3 (0)
Potassium	mg/l	244.0 (4)	215.0 (4)	252.0 (4)	94.0 (2)	146.0 (3)	122.0 (3)	162.0 (3)
Calcium	mg/l	241.0	178.0	72.0	82.0	131.0	67.0	146.0
Magnesium	mg/l	52.0 (6)	45.0 (5)	16.0 (3)	18.0 (3)	40.0 (5)	15.0 (3)	38.0 (5)
Phosphorus	mg/l	100.0 (9)	97.0 (8)	55.0 (7)	70.0 (7)	62.0 (7)	62.0 (7)	67.0 (7)
Iron	mg/l	2.45	1.27	1.33	1.82	1.90	1.27	1.35
Zinc	mg/l	2.50	3.06	2.84	2.67	2.76	3.22	2.89
Manganese	mg/l	12.21	7.48	3.54	2.95	6.28	2.81	6.87
Copper	mg/l	0.31	0.22	0.20	0.13	0.21	0.21	0.21
Boron	mg/l	<0.01	<0.01	<0.01	<0.01	0.15	0.01	<0.01
Bulk Density	g/ml	0.373	0.372	0.34	0.376	0.347	0.29	0.371
Product: Control - Levington M2								
pH		5.8	5.6	6.1	6.0	5.8	5.8	5.7
Conductivity uS/20°C		353.0 (2)	404.0 (3)	133.0 (0)	162.0 (1)	245.0 (1)	212.0 (1)	265.0 (1)
Nitrate (as N)	mg/l	114.0 (4)	154.0 (5)	37.0 (2)	36.0 (2)	85.0 (4)	40.0 (2)	72.0 (3)
Ammonium (as N)	mg/l	47.0 (1)	0.3 (0)	0.3 (0)	1.1 (0)	0.3 (0)	0.1 (0)	0.7 (0)
Potassium	mg/l	126.0 (3)	154.0 (3)	28.0 (1)	80.0 (2)	82.0 (2)	77.0 (2)	74.0 (2)
Calcium	mg/l	80.0	126.0	49.0	53.0	87.0	69.0	101.0
Magnesium	mg/l	83.0 (6)	130.0 (7)	43.0 (5)	49.0 (5)	90.0 (7)	65.0 (6)	96.0 (7)
Phosphorus	mg/l	89.0 (8)	90.0 (8)	45.0 (6)	55.0 (7)	60.0 (7)	50.0 (6)	64.0 (7)
Iron	mg/l	0.06	<0.01	<0.01	<0.01	<0.01	0.35	<0.01
Zinc	mg/l	0.23	0.16	0.08	1.11	0.20	0.34	1.66
Manganese	mg/l	0.18	0.23	0.07	0.07	0.14	0.16	0.20
Copper	mg/l	0.08	0.05	0.06	0.04	0.06	0.04	0.05
Boron	mg/l	<0.01	<0.01	0.04	0.21	<0.01	<0.01	0.10
Bulk Density	g/ml	0.272	0.257	0.471	0.438	0.293	0.22	0.337

Table 49 Leaf Tissue Analysis at Marketing for each species grown in Shamrock

		Begonia at 6 weeks	Petunia at 6 weeks	Salvia at 6 weeks	Geranium at 8 weeks	Impatiens at 6 weeks	Marigold at 5 weeks
Product: Shamrock							
Nitrogen	%	3.79	4.02	3.93	2.82	3.83	4.01
Phosphorus	%	0.469	0.805	0.686	0.555	1.186	0.786
Potassium	%	4.15	5.69	5.45	3.71	4.05	3.97
Calcium	%	1.676	1.874	2.049	1.509	3.636	2.205
Magnesium	%	0.824	0.533	0.652	0.371	0.692	0.639
Manganese	mg/kg	626.84	748.69	1134.25	765.30	1352.67	1344.46
Product: Control - Levington M2							
Nitrogen	%	3.20	4.14	4.25	3.82	4.72	4.95
Phosphorus	%	0.813	1.112	0.622	0.801	1.088	1.104
Potassium	%	6.00	6.70	4.47	3.93	3.00	5.79
Calcium	%	0.966	1.323	1.533	1.435	2.484	1.746
Magnesium	%	0.564	0.856	1.043	0.766	1.725	1.358
Manganese	mg/kg	86.48	138.10	218.13	130.31	216.88	324.49

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Table 50 **Media Analysis of Petersfield at Marketing for each species (water available - extractable analysis)**

		At Potting	Begonia at 6 weeks	Petunia at 6 weeks	Salvia at 6 weeks	Geranium at 8 weeks	Impatiens at 6 weeks	Marigold at 5 weeks
Product: Petersfield								
pH		6.2	6.0	6.1	6.2	5.9	6.2	5.8
Conductivity uS/20°C		401.0 (3)	215.0 (1)	165.0 (1)	183.0 (1)	273.0 (1)	155.0 (1)	210.0 (1)
Nitrate (as N)	mg/l	114.0 (4)	83.0 (4)	46.0 (2)	32.0 (2)	84.0 (4)	19.0 (1)	54.0 (3)
Ammonium (as N)	mg/l	78.0 (2)	0.3 (0)	0.3 (0)	0.3 (0)	2.3 (0)	1.1 (0)	1.2 (0)
Potassium	mg/l	277.0 (5)	182.0 (4)	106.0 (3)	157.0 (3)	208.0 (4)	173.0 (3)	158.0 (3)
Calcium	mg/l	52.0	54.0	58.0	60.0	79.0	31.0	57.0
Magnesium	mg/l	16.0 (3)	19.0 (3)	23.0 (3)	22.0 (3)	36.0 (5)	11.0 (2)	21.0 (3)
Phosphorus	mg/l	44.0 (6)	28.0 (4)	30.0 (5)	32.0 (5)	25.0 (4)	26.0 (4)	23.0 (4)
Iron	mg/l	6.46	6.30	7.35	9.10	13.64	34.13	21.22
Zinc	mg/l	0.63	0.26	0.30	0.38	0.51	0.46	0.33
Manganese	mg/l	0.93	0.44	0.47	0.23	0.66	0.36	0.80
Copper	mg/l	0.29	0.11	0.07	0.14	0.19	0.16	0.10
Boron	mg/l	0.13	0.07	0.07	0.12	0.14	<0.01	0.14
Bulk Density	g/ml	0.457	0.481	0.508	0.452	0.437	0.430	0.500
Product: Control - Levington M2								
pH		5.8	5.6	6.1	6.0	5.8	5.8	5.7
Conductivity uS/20°C		353.0 (2)	404.0 (3)	133.0 (0)	162.0 (1)	245.0 (1)	212.0 (1)	265.0 (1)
Nitrate (as N)	mg/l	114.0 (4)	154.0 (5)	37.0 (2)	36.0 (2)	85.0 (4)	40.0 (2)	72.0 (3)
Ammonium (as N)	mg/l	47.0 (1)	0.3 (0)	0.3 (0)	1.1 (0)	0.3 (0)	0.1 (0)	0.7 (0)
Potassium	mg/l	126.0 (3)	154.0 (3)	28.0 (1)	80.0 (2)	82.0 (2)	77.0 (2)	74.0 (2)
Calcium	mg/l	80.0	126.0	49.0	53.0	87.0	69.0	101.0
Magnesium	mg/l	83.0 (6)	130.0 (7)	43.0 (5)	49.0 (5)	90.0 (7)	65.0 (6)	96.0 (7)
Phosphorus	mg/l	89.0 (8)	90.0 (8)	45.0 (6)	55.0 (7)	60.0 (7)	50.0 (6)	64.0 (7)
Iron	mg/l	0.06	<0.01	<0.01	<0.01	<0.01	0.35	<0.01
Zinc	mg/l	0.23	0.16	0.08	1.11	0.20	0.34	1.66
Manganese	mg/l	0.18	0.23	0.07	0.07	0.14	0.16	0.20
Copper	mg/l	0.08	0.05	0.06	0.04	0.06	0.04	0.05
Boron	mg/l	<0.01	<0.01	0.04	0.21	<0.01	<0.01	0.10
Bulk Density	g/ml	0.272	0.257	0.471	0.438	0.293	0.22	0.337

Table 51 **Leaf Tissue Analysis at Marketing for each species grown in Petersfield**

		Begonia at 6 weeks	Petunia at 6 weeks	Salvia at 6 weeks	Geranium at 8 weeks	Impatiens at 6 weeks	Marigold at 5 weeks
Product: Petersfield							
Nitrogen	%	4.25	4.70	3.74	4.22	3.69	4.68
Phosphorus	%	0.529	0.726	0.612	0.571	1.261	1.130
Potassium	%	3.56	8.13	5.41	4.13	4.16	5.68
Calcium	%	1.096	1.198	1.511	1.244	2.556	1.780
Magnesium	%	0.489	0.333	0.457	0.350	0.610	0.639
Manganese	mg/kg	217.75	218.71	365.46	231.24	363.55	387.91
Product: Control - Levington M2							
Nitrogen	%	3.20	4.14	4.25	3.82	4.72	4.95
Phosphorus	%	0.813	1.112	0.622	0.801	1.088	1.104
Potassium	%	6.00	6.70	4.47	3.93	3.00	5.79
Calcium	%	0.966	1.323	1.533	1.435	2.484	1.746
Magnesium	%	0.564	0.856	1.043	0.766	1.725	1.358
Manganese	mg/kg	86.48	138.10	218.13	130.31	216.88	324.49

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Table 52 Media Analysis of Freeland Technologies at Marketing for each species (water available - extractable analysis)

		At Potting	Begonia at 6 weeks	Petunia at 6 weeks	Salvia at 6 weeks	Geranium at 8 weeks	Impatiens at 6 weeks	Marigold at 5 weeks
Product: Freeland Technologies								
pH		7.6	8.1	8.2	7.5	7.7	7.8	8.2
Conductivity uS/20°C		456.0 (3)	349.0 (2)	236.0 (1)	257.0 (1)	337.0 (2)	391.0 (2)	312.0 (2)
Nitrate (as N)	mg/l	106.0 (4)	10.0 (0)	20.0 (1)	38.0 (2)	61.0 (3)	19.0 (1)	34.0 (2)
Ammonium (as N)	mg/l	1.0 (0)	0.6 (0)	0.8 (0)	0.3 (0)	0.8 (0)	0.1 (0)	0.7 (0)
Potassium	mg/l	588.0 (6)	494.0 (6)	317.0 (5)	298.0 (5)	433.0 (6)	558.0 (6)	390.0 (5)
Calcium	mg/l	89.0	64.0	49.0	75.0	76.0	69.0	48.0
Magnesium	mg/l	14.0 (2)	10.0 (1)	10.0 (2)	16.0 (3)	14.0 (2)	9.0 (1)	11.0 (2)
Phosphorus	mg/l	25.0 (4)	31.0 (5)	24.0 (4)	29.0 (5)	25.0 (4)	25.0 (4)	22.0 (4)
Iron	mg/l	8.84	12.37	23.13	5.35	7.29	13.0	19.56
Zinc	mg/l	0.29	0.25	0.31	0.71	1.95	0.34	0.55
Manganese	mg/l	0.17	0.12	0.26	0.07	0.11	0.19	0.22
Copper	mg/l	0.21	0.15	0.11	0.08	0.08	0.13	0.15
Boron	mg/l	0.13	0.55	0.14	0.12	0.27	0.34	0.18
Bulk Density	g/ml	0.471	0.471	0.464	0.414	0.457	0.427	0.458
Product: Control - Levington M2								
pH		5.8	5.6	6.1	6.0	5.8	5.8	5.7
Conductivity uS/20°C		353.0 (2)	404.0 (3)	133.0 (0)	162.0 (1)	245.0 (1)	212.0 (1)	265.0 (1)
Nitrate (as N)	mg/l	114.0 (4)	154.0 (5)	37.0 (2)	36.0 (2)	85.0 (4)	40.0 (2)	72.0 (3)
Ammonium (as N)	mg/l	47.0 (1)	0.3 (0)	0.3 (0)	1.1 (0)	0.3 (0)	0.1 (0)	0.7 (0)
Potassium	mg/l	126.0 (3)	154.0 (3)	28.0 (1)	80.0 (2)	82.0 (2)	77.0 (2)	74.0 (2)
Calcium	mg/l	80.0	126.0	49.0	53.0	87.0	69.0	101.0
Magnesium	mg/l	83.0 (6)	130.0 (7)	43.0 (5)	49.0 (5)	90.0 (7)	65.0 (6)	96.0 (7)
Phosphorus	mg/l	89.0 (8)	90.0 (8)	45.0 (6)	55.0 (7)	60.0 (7)	50.0 (6)	64.0 (7)
Iron	mg/l	0.06	<0.01	<0.01	<0.01	<0.01	0.35	<0.01
Zinc	mg/l	0.23	0.16	0.08	1.11	0.20	0.34	1.66
Manganese	mg/l	0.18	0.23	0.07	0.07	0.14	0.16	0.20
Copper	mg/l	0.08	0.05	0.06	0.04	0.06	0.04	0.05
Boron	mg/l	<0.01	<0.01	0.04	0.21	<0.01	<0.01	0.10
Bulk Density	g/ml	0.272	0.257	0.471	0.438	0.293	0.22	0.337

Table 53 Leaf Tissue Analysis at Marketing for each species grown in Freeland Technologies

		Begonia at 6 weeks	Petunia at 6 weeks	Salvia at 6 weeks	Geranium at 8 weeks	Impatiens at 6 weeks	Marigold at 5 weeks
Product: Freeland Technologies							
Nitrogen	%	4.06	3.51	3.85	3.56	3.97	4.40
Phosphorus	%	0.559	0.590	0.577	0.544	0.703	0.702
Potassium	%	6.13	8.29	6.78	6.15	6.60	6.09
Calcium	%	0.931	1.349	1.077	1.069	1.694	1.374
Magnesium	%	0.948	0.288	0.444	0.306	0.295	0.488
Manganese	mg/kg	99.37	100.29	154.00	78.27	93.24	172.80
Product: Control - Levington M2							
Nitrogen	%	3.20	4.14	4.25	3.82	4.72	4.95
Phosphorus	%	0.813	1.112	0.622	0.801	1.088	1.104
Potassium	%	6.00	6.70	4.47	3.93	3.00	5.79
Calcium	%	0.966	1.323	1.533	1.435	2.484	1.746
Magnesium	%	0.564	0.856	1.043	0.766	1.725	1.358
Manganese	mg/kg	86.48	138.10	218.13	130.31	216.88	324.49

Elemental content of healthy bedding plants. These are guidelines only and not necessarily industry standards. (Adapted from Metcoff, 1992)

Crop	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)
Begonia	4.4-5.2	0.3-0.4	3.4-4.2	1.3-4.2	0.6-1.0	100-260	90-355	50-65	10-15	30-40
Geranium (seed)	3.7-4.8	0.3-0.6	2.0-4.8	1.1-4.5	0.4-1.0	120-340	110-285	35-60	5-15	35-60
Impatiens (common)	4.3-5.3	0.6-0.8	2.8-1.8	2.9-3.3	0.6-0.8	405-885	205-490	65-70	10-15	45-95
Impatiens (New Guinea)	3.3-4.9	0.3-0.8	1.9-2.7	1.9-2.7	0.3-0.8	160-890	140-245	40-85	5-10	50-60
Petunia	2.8-5.8	0.5-1.2	3.5-5.5	0.6-4.8	0.3-1.4	40-700	90-185	30-90	5-15	20-50
Primula (acaulis)	2.5-3.3	0.4-0.8	2.1-4.2	0.6-1.0	0.2-0.4	75-155	50-80	40-45	5-10	30-35
Snapdragon	4.0-5.3	0.2-0.6	2.2-4.1	0.5-1.4	0.5-1.0	70-135	60-185	30-55	5-15	15-40
Vinca	4.9-5.4	0.4-0.5	2.9-3.6	1.4-1.6	0.4-0.5	95-150	165-300	40-45	5-10	25-40

Source: Ornamental Bedding Plants by Allan M Armitage

COMMERCIAL - IN CONFIDENCE

Contract between HRI (hereinafter called the "Contractor") and the Horticultural Development Council (hereinafter called the "Council") for a research/development project.

1. TITLE OF PROJECT

Contract No: PC 113
Contract Date: 21.7.95

BEDDING PLANTS: EVALUATION OF REDUCED PEAT OR ALTERNATIVE PEAT-FREE SUBSTRATES FOR USE IN BEDDING PLANT PRODUCTION

2. BACKGROUND

The use of peat as a growing media in commercial horticultural production has continued to face growing pressure from environmentalists because of concerns about the loss of peat reserves and wildlife habitats. A range of alternative substrates are available for use in the amateur market but, as yet, few commercial growers of pot and bedding plants use peat-free media on a large scale.

Much research has been conducted on the use of alternative media within the Nursery Stock sector, but few have consistently performed well in trials and peat still remains the main component of growing substrate. However, continuing research is providing viable alternative media for the use by commercial growers. Bedding plant producers have had little involvement with the use peat-free media as often their use/consumption in small containers is overlooked, compared to the large quantities used in Nursery Stock.

Throughout the UK and European markets, consumers are increasingly concerned with the 'greenness' of a product and its effect on the environment in production and use. Large retailers, including the multiples within the UK, are trying to ensure that the products they supply are, as far as possible, grown without harm to the environment. Much attention has focused on the use of chemicals (pesticides, fungicides etc) and the use of peat is being reviewed. Many retailers accept that it may not be possible to replace peat completely but we would like to ensure that as much as possible is done to reduce the use of 'non-sustainable' resources.

A detailed evaluation of alternative growing media in bedding plant production needs to be made in comparison to standard peat substrate. This will provide valuable information to the industry. Further assessments will then be needed to optimise its use in terms of irrigation, fertigation and post-production handling. Many substrate manufacturers are now marketing media which are peat-free or with reduced peat content. All these need to be tested and information on their performance in comparison to pure peat conveyed to growers and consumers alike, to educate them on the pros and cons of the use of these alternative composts.

3. POTENTIAL FINANCIAL BENEFIT TO THE INDUSTRY

Provide growers technical information with regard to proper handling and use of peat-free media without risk to cropping and financial loss through mis-management.

Possible improved efficiency with use of fertilizer and improved shelf-life and garden performance of the product. Marketing advantage with promotion of a 'green' product accepted by the retailers.

4. SCIENTIFIC AND TECHNICAL TARGET OF THE WORK

Assess range of substrate types in relation to commercial standard practice of peat based media using a range of different bedding plant species.

5. CLOSELY RELATED WORK

The HDC Hardy Nursery Stock Panel has funded a number of projects in which peat alternatives have been examined, the main ones include HNS 2, 28 and 28b.

6. DESCRIPTION OF WORK

Comparison of alternative substrates to standard peat media

Substrate Types:

Nine peat-free/reduced peat media types will be tested: in comparison with a commercial standard peat compost as a 'control' (Levington M2).

No.	Product	Company
1.	Levington M2 (Control)	Levington Horticulture Paper Mill Lane, Bramford, Ipswich, Suffolk, IP8 4BZ
2.	Sunrise 15	Bulrush Peat Co Ltd Newferry Road, Bellaghy, Magherafelt, County Derry, Northern Ireland, BT45 8ND
3.	GU/BU Mix	Grodania A/S Wern Tarw, Pencoed, Bridgend Mid Glamorgan, CF35 6NY
4.	Sylvafibre/Grobark	Melcourt Industries Ltd Eight Bells House, Tetbury Gloucestershire, GL8 8JG
5.	Peat Free	Petersfield Products 45 Cambridge Road, Cosby Leicestershire, LE9 5SJ

No.	Product	Company
6.	Peat Free	Richmoor Horticulture George Street, Glastonbury Somerset, BA6 9JH
7.	Coco Compost	Roffey Bros Ltd Throop Road, Bournemouth Dorset, BH8 0DF
8.	Peat Free	Shamrock Horticulture The Crescent Centre, Temple Back Bristol, BS1 6EZ
9.	Coir	William Sinclair Horticulture Ltd Firth Road, Lincoln, LN6 7AH
10.	Coir	Wessex Horticultural Products Ltd South Newton, Salisbury, Wiltshire, SP2 0QW

Container Size:

Final marketing pack - double six

Plant Species - total 6:

Geranium	Century Scarlet
Salvia	Vanguard
Marigold	Aurora Fire
Impatien	Accent Salmon
Begonia	Olympia Red
Petunia	Express Blue

Culture:

All plants will be sown in 286 plug trays (except Geranium which will be produced in 180 plug trays) at HRI Efford using F1-Levington peat substrate. Plants will be treated equally in terms of nutrition, watering etc and pricked-off accordingly when plants can be handled easily.

Plants pricked-off into each media type and grown on the floor 'Q' Block at HRI Efford. Plants will be treated as per the 'control', standard peat substrate, this includes nutrition and frequency of irrigation which will be overhead by hand. Appropriate growing temperatures will be applied until marketing.

Design:

10	media types (including control)
x	
6	species
x	
1	container size (double six)
x	
2	replicates
120	plots

Plot size: Each plot will total 9 double six packs arranged 3 x 3 - central box of 12 plants to be recorded with two replicates, total 24 plants.

Garden Performance: 12 plants will be planted out to determine any variation upon establishment or growth from each of the substrates.

Assessments:

a. Media analysis.
For each media type at:
'pricking-off'/commencement
at 4/6 weeks
at maturity/marketing

b. Plant Growth Records.
At 6 weeks:
Plant height
Quality/uniformity score
Foliage score
Root assessment score

At maturity/marketing (inc. time to marketing)
Plant height
Quality/uniformity score
Foliage score
Flowering score
Root assessment score
% Dry matter

c. Garden performance.
Visual assessment of plant quality at 4, 8 and 12 weeks post planting.

d. Photographs at all appropriate stages.
At 4/6 weeks and at marketing.

e. Full environmental records.

f. Crop diary.

7. START DATE, DURATION AND REPORTING

Start date, 01.02.95; duration 10 months

The experimental work will be completed by September 1995 and the final report produced by November 1995.

It is possible that further work will be required in 1996 so that the most promising peat free/reduced peat media can be examined in more detail.

8. STAFF RESPONSIBILITIES

Project Leader: Andrew Fuller, HRI Efford

Project Co-ordinator: Mr Nigel Waite

9. LOCATION

HRI - Efford, Lymington, Hampshire

Each manufacturer will provide their product free of charge and will cover the expenses incurred for substrate and tissue analysis (estimated at £200-£300 for each growing media/species). The full results will only be made available to Corporate members of the HDC. The other manufacturers will only receive information on the performance of their own product.

TERMS AND CONDITIONS

The Council's standard terms and conditions of contract shall apply.

Signed for the Contractor(s)

Signature.....

Position C & M Manager HRI

Date 11/1/96

Signed for the Contractor(s)

Signature.....

Position.....

Date.....

Signed for the Council

Signature.....

Position CHIEF EXECUTIVE

Date 31.7.96