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CONTRACT REPORT

Bedding Plants: Investigation of cultural methods for controlling height

HDC PC86

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Bedding Plants: Investigation of cultural methods for controlling height

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CONTENTS

RELEVANCE TO GROWERS AND PRACTICAL APPLICATION

Application

The aim of this study was to examine the use of nutrition (phosphate) and water as methods to control plant height.

A range of bedding plant species were grown in a peat based substrate which had controlled levels of single superphosphate to examine the effect on plant growth, specifically the control of height. The results demonstrated that the use of restricted phosphate can be used as a cultural tool to control plant height. A watering regime imposed after the plants had been transplanted into their final containers, whereby plants were grown under a 'dry' regime further restricted plant height throughout all phosphate treatments. Plant height was reduced by up to 50% in *Petunia* as an average across phosphate treatments and a 70% saving in water use was achieved.

Summary

Chemical plant growth regulators are one of the most commonly used methods of controlling height in pot and bedding plants to provide a high quality, compact plant for marketing. In recent years concern has increased over the high chemical input into crops and the potential for pollution, which in the future may lead to restrictions through legislation. Several alternative methods are being investigated to reduce plant height including the use of temperature control (DIF/DROP). Although successful, particularly with pot plants, this method is often species dependant and is not always practicable to achieve at certain times of the year.

The use of controlled phosphate deficiency and water tension has been the subject of trials particularly in Europe. In 1993, at HRI Efford, a first study investigated the use of limited phosphate and water 'stress' as methods for plant height control. On review of this first trial it was concluded that the phosphate treatments had become contaminated with trace phosphates from the liming source and lateral movement of phosphates within capillary matting and the results could not be relied upon. However, the watering regimes clearly demonstrated the ability to reduce plant height by limiting water availability. In 1994, a second study using a greater range of bedding plant species investigated the use of phosphate levels ranging from zero rate up to 3 kg/m^3 single superphosphate with the use of pure calcium carbonate as the liming agent instead of ordinary limestone. In addition, a 'standard' and 'dry' watering regime were imposed after transplanting.

Eight species were trialled: Alyssum, *Lobelia*, *Mesembryanthemum*, Pansy, *Impatiens*, Marigold, *Petunia* and *Salvia*.

These were grown using a fine Bulrush Peat substrate with the following base mix:

Product	**grammes per litre substrate**
Ammonium Nitrate	0.40
Potassium Nitrate	0.75
Fritted Trace Element 255	0.40
Calcium Carbonate (99.9%)	3.00
Plus Wetting Agent (Aquagro)	

The following treatment levels of single superphosphate were included in the substrate during the plug and growing-on stage:

1. 0.0 kg/m^3
2. 0.5 kg/m^3
3. 1.0 kg/m^3
4. 2.0 kg/m^3
5. 3.0 kg/m^3

At transplanting into the same substrate mixes, the standard/dry watering regimes commenced.

A. Standard commercial practice, i.e. watered frequently as deemed necessary, not allowed to wilt.

B. Dry regimes in which plants were allowed to dry back until flaccid before watering lightly overhead.

All seed was hand sown in 286 plug trays and propagated at 20°C. Plant species Alyssum, *Lobelia*, Pansy and *Mesembryanthemum* were grown on at temperature set point 12°C, with venting at set point 14°C. Species *Petunia, Salvia,* Marigold and *Impatiens* were grown on at 16°C, with venting at 18°C.

All plants were liquid fed with equal ratio of N:K feed. No phosphate was applied at any stage other than in the main treatments.

Plant growth records were taken at transplanting stage and also at maturity (marketing stage).

The present commercial rate of single superphosphate for inclusion in bedding plant growing media is 1.5 kg/m^3. Complete omission of phosphate fertilizers produced the greatest height control for all species. At zero phosphate, germination of seed was unaffected, and plant growth became 'checked' as the seeds reserve of phosphate was exhausted. Applications of phosphate fertilizers below the commercial rate, at 0.5 kg/m^3 and 1.0 kg/m^3 single superphosphate also limited plant growth in some species. Plants grown at zero phosphate remained compact and small throughout the trial. Although height control was also possible with the use of increased rates of phosphate, 2.0 kg/m^3 and 3.0 kg/m^3, height control was not as effective as seen at the lower rates, and the use and cost of extra fertilizers is unjustified. Throughout all species a 'peak' in growth was apparent at a level between 1.0 kg/m^3 and 2.0 kg/m^3 single superphosphate.

Leaf tissue analysis demonstrated phosphate was the limiting mineral affecting plant growth.

Growth responses seen at transplanting stage were continued, until maturity in the majority of species. Plant growth was greatest between 1.0 kg/m^3 and 2.0 kg/m^3 single superphosphate, levels above and below reduced plant height, vigour and leaf area. Although plants were generally smaller, the control of height prevented excessively 'soft/leggy' growth and plant quality remained good.

The 'dry' watering regime reduced plant growth across all species and phosphate treatments. Plant height was reduced significantly and the amount of water applied was reduced on average by 70%.

With the exception of plants grown at zero phosphate which were too small at final records, plants were planted outside in a prepared soil bed to examine treatment effect upon plant establishment and garden performance. No consistent differences between treatments were obvious other than that plants grown under the 'dry' watering regime were much smaller and harder, and could withstand handling better.

The results to date demonstrate the ability to control plant height through controlled levels of phosphate fertilizers in the growing media. Complete omission of phosphates from the growing media has the greatest control on plant growth but plug plants cannot easily be removed from their modules due to the reduced rooting. Control of irrigation is a further measure which can be used to control plant growth. The results thus far are evaluated further in 1995 to examine the use of rates of single superphosphate below 1.0 kg/m^3 in conjunction with the application of high phosphate liquid feeds to reactivate plant growth.

Key Conclusions

- Restricted phosphate levels can be used to control plant height across a range of bedding plant species.
- Zero phosphate gives the greatest control of plant height/growth, but plants cannot easily be 'pulled' from the plug tray.
- 0.5 kg/m^3 - 1.0 kg/m^3 single superphosphate will limit plant growth without severely affecting plant quality either in the plug stage or at the point of sale.
- All species were successfully grown under all the treatments applied.
- Use of water 'stress' can be used as a further method to control plant growth successfully in the final container.
- A 'dry' watering regime may reduce the volume of water to be applied by up to 70%.

EXPERIMENTAL SECTION

INTRODUCTION

Plant growth regulators are one of the most commonly used methods of controlling pot and bedding plants to provide a high quality, compact plant for marketing. In recent years concern has increased over the high chemical input into crops and the potential for pollution, which in future may lead to restrictions through legislation. Several alternative methods are being investigated to reduce plant height, including the use of temperature control (DIF/DROP). Although successful, particularly with pot plants, this method is often species dependant, and is not always practicable to achieve at certain times of year.

The use of controlled phosphate deficiency has been the focus of trials in Denmark and in the Netherlands, and trials at Osnabrück have evaluated water tension as a method to control plant growth. Alternative methods for height control using manipulation of nutrition (phosphate), plug size and the use of water stress on plants formed the basis of a trial at HRI Efford in 1993. The use of a controlled phosphate deficiency proved less effective in this first trial than had been predicted, both during the plug stage and growing on. Upon investigation it was concluded that the source of ground limestone as liming agent was not 100% pure, and had contributed extra phosphates to the substrate. In addition, the use of capillary matting under plug trays facilitated lateral movement of phosphates in solution, contaminating neighbouring treatments. As a result, there was little confidence in the data collected from applied treatments of phosphate in 1993. However, marked height control was demonstrated with the use of water stress during the growing on phase.

On review of the first trial in 1993 and the conclusion that phosphate treatments had not been successfully applied throughout the plug and growing on stages, a second trial in 1994 was commissioned to further evaluate and quantify the use of water stress, and again assess the use of phosphate nutrition as a tool to control plant height on a wider range of species than used in the first trial.

As with all trials, shelf-life/garden performance was included to observe any favourable or detrimental effects of treatments in the longer term.

OBJECTIVES

The objectives were:

- To examine the use of limited phosphate as a method to control plant height in a range of bedding plant species.

- To evaluate and quantify the use of watering regimes to control plant height.

- To assess the garden performance of plants subjected to the various phosphate/watering treatments.

MATERIALS AND METHODS

Year: 1994

Site

Seeds were sown in the propagation area of 'H' Block at HRI Efford. Once the first true leaves had fully expanded, the seedlings were transferred to two compartments of 'K' Block and grown on weld mesh benches to avoid lateral movement of phosphates due to leaching.

Start material

Seeds for the trial were purchased from Colegraves Seeds Ltd.

Species

Lobularia maritima (Alyssum) cv. Snowdrift
Lobelia erinius cv. Crystal Palace
Mesembryanthemum criniflorum cv. Magic Carpet mixed
Viola x. wittrockiana (Pansy) cv. F1 Turbo Blue-White Bicolour
Impatiens walleriana cv. F1 Accent Salmon
Tagetes patula (Marigold) cv. Aurora Fire
Petunia hybr. cv. F1 Express Blue Star
Salvia splendens cv. Vanguard

Treatments

Levels of phosphate used during plug and growing-on stage

(Single superphosphate (SSP) kg/m^3)

1. 0 kg/m^3
2. 0.5 kg/m^3
3. 1.0 kg/m^3
4. 2.0 kg/m^3
5. 3.0 kg/m^3

Watering regime during growing-on

A. Standard commercial practice, i.e. watered frequently as deemed necessary, not allowed to wilt.

B. 'Dry' regime in which plants were allowed to dry back until flaccid before watering lightly overhead.

Experimental design and layout

The experiment layout within each compartment is illustrated in Figures 1a and 1b, Appendix I, pages 26 and 27. Phosphate treatments were replicated twice and laid out in a randomised manner within each species block. The watering regime was divided between the two benches in each compartment.

Preliminary observation with limited replication.

5	phosphate levels
x	
2	watering regimes during growing-on
x	
2	replicates
--	
20	plots/species
x	
8	species

160	plots in total

Plot size: 20 plants recorded from centre of each plug tray.
12 plants recorded from double-six growing tray.

Cultural Details

All seed was hand sown in 286 plug trays (20 x 20 x 20 mm) using Bulrush fine peat amended as follows:

Product	grammes per litre substrate
Ammonium Nitrate	0.4
Potassium Nitrate	0.75
Fritted Trace Elements 255	0.4
Calcium Carbonate (99.99%)	3.0
Plus wetting agent (Aquagro)	

Plus single superphosphate at specified rate in treatments.

See Table 1, Appendix II page 28 for analysis of growing media at sowing.

A base temperature of 20°C was maintained throughout propagation. Upon emergence, the species Alyssum, *Lobelia*, Pansy and *Mesembryanthemum* were transferred to one compartment in 'K' Block with day/night temperature set points of 12°C and a venting set point of 14°C. Species *Petunia*, *Salvia*, Marigold and *Impatiens* were transferred to an identical compartment in 'K' Block and grown on at 16°C day/night and venting at 18°C. See Table 2, Appendix III page 29 for crop diary.

The plugs received liquid feed as follows:

Product	kg/100 litres
Ammonium Nitrate	2.95
Potassium Nitrate	3.40

Dilute 1:200 to give 75N:75K mg/litre

Liquid feed was applied by hand lance overhead at every watering.
In the growing-on stage this was increased to 150N:150K.

Pansy received sprays of benomyl as Benlate at 0.5 g/l on 29 March and sprays of chlorothalonil as Repulse at 2.2 g/l on 8 April for control of *Botrytis*.

Records were taken at transplanting stage when plants could be easily 'pulled' by hand from the plug tray. Plants were transplanted into double six polystyrene boxes, with a cell size of 367 x 225 x 65 mm. Each cell contained the same growing media treatment applied in the plug stage. Plants were grown under either a standard or 'dry' watering regime until marketing when final plant growth assessments were recorded.

Biological control agents employed throughout the course of the study included:

Amblyseius cucumeris	for	Western Flower Thrips
Phytoseiulus persimilis	for	Two spotted Spider Mite
Aphidius colemani	for	Aphids
Aphidoletes aphidimyza	for	Aphids
Encarsia formosa	for	Glasshouse Whitefly (*Trialeuroides vaporirum*)

No chemical pesticides were necessary.

Assessments

Plug stage

At the plug stage immediately prior to transplanting full assessments were made. These included:

Plant height (mm)
Plant quality (1-3, 3 = best)
Plant vigour as a function of leaf size:
1 = largest leaf < 15mm long
2 = largest leaf 15-25mm long
3 = largest leaf > 25mm long
Rooting Score (1-4, 4 = excellent)
Leaf area (cm^2)
Fresh weight (g)
Percentage dry matter content
Leaf analyses
Photographs of treatment comparisons for each species

Maturity

At maturity (marketing stage) further assessments were made. These included:

Plant height (mm)
Plant quality (1-3, 3 = best)
Flowering score (1-3, 3 = most flowers)
Compost and leaf analyses for one species (*Petunia*)
Plant/box weight (kg)
Photographs of treatment comparisons for each species

At transplanting and growing-on, records of the amount of irrigation were recorded on a regular basis for each watering regime. The amount of irrigation water applied was calculated by weighing the plot/double six box (12 plants) prior to applying irrigation water as per each treatment (standard or 'dry' watering regime), and re-weighing the box after any surplus water had drained from the bottom of the box. The difference between the two weight measurements provided the amount of water (in litres) which had been applied to the plot box.

Garden performance

Six plants from each plot were planted outdoors in a prepared soil bed, and observations on plant establishment and quality recorded over a 3 month period.

Statistical Analysis

Statistical analysis was limited as the size of the trial did not allow for complete replication of all treatments throughout the trial. Phosphate treatments in the plug stage were replicated and fully randomised within each block. At maturity, comparisons could be made between treatments within each species. Where possible data records were analysed using standard Analysis of Variance (ANOVA). The degrees of freedom (d.f.), standard error (SED) and least significant difference to 5% (LSD) on which the significance tests were based are presented in the tables in the appendices to aid interpretation of the results. Statistical terms referred to are:

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

A statistical term easier to interpret:

LSD 5% = The least (minimum) difference when comparing two means within a given column that is required for the means to be statistically different.

N.S. = Not Significant.

RESULTS

Pansy F1 'Turbo Blue-White Bicolour'

Transplanting Stage

Plant growth results are given in Table 3, Appendix IV, page 30. Plant height was significantly reduced at zero phosphate. Plug plants were much 'harder' in appearance, and were not prone to 'stretching' in the plug tray. 2.0 kg/m^3 provided a significant reduction in height compared to 0.5 kg/m^3 , 1.0 kg/m^3 and 3.0 kg/m^3. The level of 0.5 kg/m^3 produced the best quality plug plants with greatest vigour, leaf area and fresh weight. Plate 1, Appendix IX on page 48 shows the effects of phosphate treatments at transplanting. Rooting was reduced at zero phosphate and plants could not easily be 'pulled' from the plug module.

Foliage analysis is given in Table 13, Appendix V, page 34. With the exception of 3.0 kg/m^3, all levels of phosphate as percentage of dry plant tissue increased proportional to the applied phosphate treatments. Levels of nitrogen were all slightly below the recognised optimum level of 4.46%N (Dight, 1977). Slight leaf yellowing was noted at the higher rates of phosphate treatments 2.0 kg/m^3 and 3.0 kg/m^3. All other elements were satisfactory and were not consistently different between phosphate treatments.

Maturity

Results are given in Table 19, Appendix VI, page 38. Plant growth observations recorded at transplanting stage continued through until maturity. The largest plants were produced at 1.0 kg/m^3. These plants were judged to be of the best quality and had produced slightly more flowers than the other treatments, except 3.0 kg/m^3 which had the same flower score at maturity. Plants in zero phosphate remained exceptionally small. Measurements of height at maturity were below that recorded at transplanting. This can be attributed to the depth of planting at transplanting into the double six box. Plant growth was reduced at levels below and above 1.0 kg/m^3. Plants at 0.5 kg/m^3 were more compact.

Plate 4, Appendix IX, page 51 clearly shows the effect of the phosphate treatments and the watering regime applied from transplanting. Across all phosphate treatments plant growth was reduced under the 'dry' watering. Records of the total amount of water applied to each phosphate treatment from transplanting to maturity are given in Table 31, Appendix VIII, page 45. On average, across all phosphate treatments, 84% less water was applied under the 'dry' watering regime. For both watering regimes, 1.0 kg/m^3 phosphate produced the best quality plants. Under the 'dry' watering regime, plant height was reduced by 39% at 0.5 kg/m^3, 35% at 1.0 kg/m^3, 19% at 2.0 kg/m^3 and 25% at 3.0 kg/m^3.

All pack weights were significantly increased under the standard watering regime, with 1.0 kg/m^3, 2.0 kg/m^3 and 3.0 kg/m^3 significantly higher in weight than zero and 0.5 kg/m^3 phosphate. Plants at zero phosphate from both watering regimes and at 0.5 kg/m^3 from the 'dry' watering regime were reduced in size to such an extent that they were not marketable.

Garden performance

There were no significant differences in performance of plants from either watering regimes, or each phosphate treatment. Zero phosphate plants from both watering regimes were not planted out due to their small size.

Mesembryanthemum 'Magic Carpet Mixed'

Transplanting Stage

Results of plant growth assessments are given in Table 4, Appendix IV, page 30, and treatment comparisons are shown in Plate 1, Appendix IX, page 48.

Plant growth was significantly reduced at zero phosphate. Plant quality, vigour, leaf area and fresh weight were all reduced. Rooting was excellent for 0.5 kg/m^3, 1.0 kg/m^3 and 2.0 kg/m^3, and the best quality plants were produced at 0.5 kg/m^3 with best rooting and darker colour foliage. Plant quality, leaf area and fresh weight were reduced at 2.0 kg/m^3 and 3.0 kg/m^3. All plants could be pulled easily from the plug tray, although removal was slower from the zero phosphate treatment.

Foliage analysis is given in Table 12, Appendix V, page 34. Phosphate as a percentage of dried plant material was proportional to the applied phosphate treatments and levels of nitrogen and potassium were satisfactory. At 0.5 kg/m^3, nitrogen level was slightly lower than for the other phosphate treatments, but due to the absence of replication of analyses it is impossible to determine if this is significant. Overall, foliage colour appeared good, with slight yellowing apparent at 3.0 kg/m^3.

Maturity

Results are given in Table 20, Appendix VI, page 38. The effect of phosphate treatments continued to be evident. Zero phosphate plants had not grown at all, yet were still alive. Plate 4, Appendix IX, page 51 shows clearly the effects of the phosphate/watering treatments. The largest plants were recorded at 2.0 kg/m^3 with a significant reduction in height under the 'dry' watering regime. Plant quality remained good throughout all treatments (with the exception of zero phosphate for both watering regimes.) Pack weight was greatest under the standard watering regime. The 'dry' watering regime received on average across all phosphate treatments 72% less water. Records of watering regimes are given in Table 32, Appendix VIII, page 45. The 'dry' watering regime produced 'harder' plants which were not as susceptible to damage in handling, as the plants grown under the standard watering regime, however, plants did not fully cover the box and would not visually appear to give value for money to the customer. Plants were not in flower at final record stage.

Garden performance

All plants performed well when planted outside, with the exception of zero phosphate plants which were excluded from the assessment due to their small size. Plants grown under the 'dry' watering regime remained more compact and uniform in comparison to plants grown under a standard irrigation regime.

Alyssum 'Snowdrift'

Transplanting

Results are given in Table 5, Appendix IV, page 31 and Plate 1, Appendix IX, page 48 show treatment comparisons at transplanting.

Zero phosphate produced the smallest plants with reduced vigour, leaf area and fresh weight. The tallest plants were produced at 2.0 kg/m^3 with greatest vigour and fresh weight. Rooting was also superior at 2.0 kg/m^3. 1.0 kg/m^3 produced a significant height reduction in comparison to 0.5 kg/m^3 and 2.0 kg/m^3, and similarly plant leaf area and fresh weight were reduced. All plants could be pulled easily from the plug with the exception of plants grown at zero phosphate which required careful handling.

Foliage analysis is given in Table 13 Appendix V, page 35. Levels of nitrogen are below that recommended for optimum growth (Dight, 1977) across all phosphate treatments except zero. Slight leaf yellowing was evident at 2.0 kg/m^3 and 3.0 kg/m^3. Phosphate levels as percentage of dry plant tissue are in line with applied treatments and growth control can be attributed to restricted phosphate levels.

Maturity

Results are given in Table 21, Appendix VI , page 39 and Plate 5, Appendix IX, page 52 shows treatment comparisons at maturity.

Plant growth was halted at zero phosphate and no further growth was generated after transplanting. Plants grown at a phosphate level of 0.5 kg/m^3 from each watering regime were significantly smaller in height than those grown at 1.0 kg/m^3, 2.0 kg/m^3 or 3.0 kg/m^3. Flowering was delayed at 3.0 kg/m^3 in both watering regimes and quality was poorer. The best quality plants were produced at 1.0 kg/m^3, although plants at all phosphate levels (excluding zero) were marketable. Flowering was slightly reduced under the 'dry' watering regime but was not thought to be commercially significant. Mean pack weight was greatest throughout phosphate treatments under the standard watering regime. Records of watering regimes are given in Table 33, Appendix VIII, page 45. On average a 57% reduction in water was applied with the 'dry' watering regime.

Garden performance

Zero phosphate plants were not planted out due to their small size. Plants grown under the 'dry' watering regime were 'harder'. After one month planted outside no differences between treatments were apparent, and all plants were of good quality.

Salvia splendens 'Vanguard'

Transplanting

Results are given in Table 6, Appendix IV, page 31 and Plate 2, Appendix IX, page 49 show treatment comparisons at transplanting.

Unfortunately, slight stretching occurred prior to transplanting records and pricking-off. However, this only further highlighted the effect of zero phosphate to control plant height. A rate of 2.0 kg/m^3 produced the tallest plants. Plant height was reduced at the higher levels of phosphate specifically 3.0 kg/m^3. Rooting, plant vigour and fresh weight were greatest at 2.0 kg/m^3. All plants could be transplanted easily from the plug module.

Foliage analysis at transplanting is given in Table 14, Appendix V, page 35. Levels of phosphate as percentage of dry leaf tissue correlate closely to applied phosphate treatments. Levels of nitrogen are below the optimum level of 4.48% DM for plant growth (Dight, 1977). Slight leaf yellowing was obvious at levels above 1.0 kg/m^3.

Maturity

Results are given in Table 22, Appendix VI, page 39 and are shown in Plate 5, Appendix IX, page 52. Plant growth responses observed at transplanting continued to maturity. Plants grown at a rate of 2.0 kg/m^3 were significantly taller under the standard watering regime and flowering was advanced at both 2.0 kg/m^3 and 3.0 kg/m^3. Plants in zero phosphate remained alive, but were very small and unmarketable. Plants at 0.5 kg/m^3 were smaller than those grown at high phosphate levels. This was exaggerated under the 'dry' watering regime.

Plants grown under the 'dry' watering regime developed darker, harder looking foliage which tended to be more glossy and was not as prostrate as those of the standard watering regime. Results for the watering regime are given in Table 34, Appendix VIII, page 46. On average, across all phosphate treatments 65% less water was applied to plants grown in the 'dry' watering regime. Plants were smaller in height with reduced plant quality and flowering. Pack weight was significantly reduced under the 'dry' watering regime.

Garden performance

Taller plants suffered more from wind damage immediately after planting outside, but no consistent differences were found between treatments and all plants grew satisfactorily. (Plants from zero phosphate, and from both watering regimes were not planted out due to their small size).

Marigold 'Aurora Fire'

Transplanting

Results are given in Table 7, Appendix IV, 32 and Plate 2, Appendix IX, page 49 show treatment comparisons at the plug stage.

Zero phosphate produced a significant reduction in height. All other treatments produced plants around 45 mm $\pm$ 3 mm in height. Zero phosphate plants were sturdy with reduced leaf area and fresh weight. Plants grown at 3.0 kg/m^3 had greatest vigour, leaf area and fresh weight and were thought to be of the best quality. Rooting was superior at 1.0 kg/m^3 and above, although all plants could be easily pulled from the plug modules, including plants grown at zero phosphate.

Foliage analysis is given in Table 15, Appendix V, page 36. Phosphate as percentage of dry plant tissue increased in proportion to applied phosphate treatments. All other nutrient elements were in a satisfactory range for plant growth. Purpling of foliage was visible at zero phosphate.

Maturity

Results are given in Table 23, Appendix VI, page 40 and Plate 6, Appendix IX, page 53 shows treatment comparisons at maturity.

Plant height was significantly reduced at zero phosphate and plants at 0.5 kg/m^3 were smaller than plants grown at higher phosphate levels. The best quality plants were produced at 1.0 kg/m^3, 2.0 kg/m^3 and 3.0 kg/m^3 under the standard watering regime. Quality was reduced throughout all phosphate treatments under the 'dry' watering regime. Mean pack weight was significantly higher at 1.0 kg/m^3 from the standard watering regime.

Records of watering regimes are given in Table 35, Appendix VIII, page 46. A 52% reduction in water was recorded under the 'dry' watering regime. Flowering was slightly advanced at 1.0 kg/m^3 in the standard watering regime, and at 0.5 kg/m^3 in the 'dry' watering regime. Plant growth generally was significantly reduced with the 'dry' watering regime, and plant growth had not completely covered the box in any phosphate treatment.

Garden performance

There were no significant differences between treatments after planting out. All plants grew well and flowered freely. Plants grown under the 'dry' watering regime remained smaller, but plant quality was good.

Lobelia erinus 'Crystal Palace'

Transplanting

Results are given in Table 8, Appendix IV, page 32 and comparison of treatments are shown on Plate 2, Appendix IX, page 49.

Zero phosphate significantly reduced plant growth. All plants were smaller, with reduced vigour, leaf area and fresh weight. Plant height was significantly reduced at 1.0 kg/m^3 in comparison to 0.5 kg/m^3 and higher phosphate rates. Plant quality was best at 1.0 kg/m^3. There was little difference between phosphate treatments above zero in terms of plant vigour, fresh weight and percentage dry matter content. Rooting was best at 0.5 kg/m^3 and 1.0 kg/m^3, and all plants could be easily pulled from the plug tray, including zero phosphate plants.

Foliage analysis is given in Table 16, Appendix V, page 36. Levels of phosphate as percentage of dry matter correlate closely to the applied phosphate treatments. Both nitrogen and potassium levels are satisfactory. Foliage colour was distinctly darker at zero and 0.5 kg/m^3 with purpling of the leaves.

Maturity

Results are given in Table 24, Appendix VI, page 40 and treatment comparisons at marketing are shown in Plate 6, Appendix IX, page 53.

Zero phosphate plants had not grown since transplanting. There was little difference in plant height across 0.5 kg/m^3, 1.0 kg/m^3 and 2.0 kg/m^3, but plant height was reduced at 3.0 kg.m^3. Overall plant size was smaller at 0.5 kg/m^3, and the best plant quality recorded at 1.0 kg/m^3. Plants grown under the 'dry' watering regime were much smaller and plant growth not as uniform, mean pack weight was also significantly reduced. Watering regime records are given in Table 36, Appendix III, page 46. 65% less water was applied under the 'dry' watering regime. No differences in flowering were observed.

Garden Performance

All plants, with the exception of zero phosphate plants (which were too small), were planted outside. Plants grown under the standard watering regime were easier to handle at planting and were seen to establish themselves better. After one month, no visible differences were apparent.

Petunia hybr. 'F1 Express Blue Star'

Transplanting

Results are given in Table 9, Appendix IV, page 33 and Plate 3, Appendix IX, page 50 show treatment comparisons.

Plant height was significantly reduced at zero phosphate. The tallest plants were produced at a rate of 0.5 kg/m^3 with greatest vigour, quality, leaf area and fresh weight. At higher rates of applied phosphate plant height was reduced and quality deteriorated proportional to the increase in phosphate treatment level. Plant vigour and leaf area were reduced at 1.0 kg/m^3 and above. Rooting was good at 0.5 kg/m^3 and above, and all plants could be easily 'pulled' from the plug module with the exception of zero phosphate plants which required careful handling.

Foliage analysis is given in Table 17, Appendix V, page 37. Levels of nitrogen were below that recommended by Dight (1977) but no leaf yellowing was apparent and all other mineral elements were at levels satisfactory for growth. Phosphate levels as percentage of dry leaf material correlated closely with applied phosphate treatments.

Maturity

Results are given in Table 25, Appendix VI, page 41 and treatment comparisons are shown in Plate 7, Appendix IX, page 54. Plant growth was reduced significantly at zero phosphate and plants at 0.5 kg/m^3 were significantly smaller in height compared to 1.0 kg/m^3, 2.0 kg/m^3 and 3.0 kg/m^3. Tallest plants were at 2.0 kg/m^3. Plant height under the 'dry' watering regimes was clearly reduced across all phosphate treatments. Plant habit was observed to be better at 0.5 kg/m^3 under the standard irrigation regime and plants from this treatment flowered 5-7 days ahead of plants in all other treatments. Plant quality was judged better at 2.0 kg/m^3 and 3.0 kg/m^3 due to the increase in overall plant size.

Watering regime records are given in Table 37, Appendix VIII, page 47. Plants grown with a 'dry' watering regime received 70% less water and on average plant height was reduced by 51% across all phosphate treatments.

Foliage analysis results from both standard and 'dry' watering regimes are given in Tables 29 and 30, Appendix VII, page 44. Levels of phosphate as percentage of dried leaf tissue correlated closely with applied phosphate treatments. All other mineral elements were at satisfactory levels for plant growth and although no firm conclusions could be drawn because of no sample replication, the effects on plant growth could be attributed to the phosphate treatments.

A set of growing media samples were analysed from the standard and 'dry' watering regimes for observation. These results are given in Tables 27 and 28, Appendix VII, pages 42 and 43. Due to the absence of sample replication only general observations are possible. Phosphate levels proportionally increased with the applied phosphate treatments in both watering regimes. All other mineral elements showed no consistent differences and were all in an acceptable range.

Garden Performance

All plants, with the exception of zero phosphate plants (due to their small size) were planted outside. All plants established well. Plants grown under the 'dry' regime and those more compact at marketing, 0.5 kg/m^3, remained more compact and were less prone to wind/rain damage throughout the assessment. No other consistent differences were recorded.

Impatiens walleriana **'F1 Accent Salmon'**

Transplanting

Results are given in Table 10, Appendix IV, page 33. Plant height was reduced at zero and 3.0 kg/m^3 with tallest plants at 2.0 kg/m^3. Plant quality was improved at the lower phosphate rate, 0.5 kg/m^3, and plants were not as liable to stretch at 0.5 kg./m^3 or at zero phosphate. Plant vigour, leaf area and fresh weight were all significantly higher at 2.0 kg/m^3. Plant 'stretching' in the plug was visible at transplanting from 1.0 kg/m^3 and 2.0 kg/m^3. Rooting was best at 1.0 kg/m^3 and 0.5 kg/m^3. All plants could easily be 'pulled' from the plug module, including zero phosphate plants.

Treatment comparisons are given in Plate 3, Appendix IX, page 50.

Foliage analysis is given in Table 18, Appendix V, page 37. Both nitrogen and potassium levels were below those recommended by Dight (1977) of 5.6% DM and 3.5% DM respectively. Slightly yellowing of foliage was noticeable at 3.0 kg/m^3.

Maturity

Results are given in Table 26, Appendix VI, page 41. Largest plants were at 1.0 kg/m^3 in both watering regimes with plant growth reduced at higher and lower phosphate treatment levels. Plants at zero phosphate remained very small and had not grown, although all plants were alive. Best quality plants were judged to beat 1.0 kg/m^3. There was no consistent treatment effect upon flowering for either phosphate and/or watering regimes. Treatment comparisons are given in Plate 7, Appendix IX, page 54.

Watering regime records are given in Table 38, Appendix VIII, page 47. Plant height was reduced across all phosphate treatments under the 'dry' watering regime. 70% less water was applied during this 'dry' regime and on average plant height reduced by 26%. Plant height was significantly reduced at 2.0 kg/m^3 and 3.0 kg/m^3.

Garden Performance

All plants were planted outside, including plants grown at zero phosphate. Although these plants could not be handled easily due to their small size, these plants established themselves and grew well. All other plants established well and no significant differences were observed between their growth and flowering.

DISCUSSION

From this year's work it is clear that phosphate nutrition is important for the growth of plants and by altering its availability it can be used as a method to control plant growth and specifically height. All plant species germinated successfully in every phosphate treatment, however, at zero phosphate, plant growth slowed and halted once the seeds' reserve of phosphate had become exhausted. This 'running out' of phosphate became apparent in the final containers whereby plants grown at 0.5 kg/m^3 were significantly smaller than those at higher phosphate levels. Plant height was reduced at low phosphate levels 0 - 0.5 kg/m^3, and at levels above that presently used commercially, 1.5 kg/m^3. The largest plants were produced at either phosphate levels of 1.0 kg/m^3 or 2.0 kg/m^3. In the case of *Petunia*, plants at transplanting stage from 0.5 kg/m^3 were the largest, but at final records at marketing, these plants were significantly smaller and more compact, with greater plant quality and earlier flowering.

With the specific aim to control plant height, the use of zero phosphate produced the greatest control, and avoided loss of plant quality in the plug stage through plant stretching, commonly a problem for commercial growers. Both *Salvia* and *Impatiens* at phosphate levels above zero tended to stretch in the plug, with a consequent loss in plant quality. However, plant growth remained excessively compact without applied phosphate, and plant growth records for all species at maturity were not very different to those taken at transplanting for the zero phosphate treatment. A level of 0.5 kg/m^3 provided height control over the period of cropping for all species, and maintained a reduction in final plant height. Similar results can be obtained with the use of elevated levels of phosphate >2.0 kg/m^3, but this cannot be justified due to the extra cost incurred with the increased use of phosphates, which are themselves a non-renewable resource.

Foliage analysis at the transplanting stage for each species demonstrated that the different levels of phosphate found in the dried leaf tissue corresponded closely with the applied phosphate treatments, and a steady increase in phosphorus in the leaf tissue occurred as the treatment level of single superphosphate increased. In some instances the levels of nitrogen and potassium were lower than recommended by Dight (1977) but were not thought to be at levels which would give rise to deficiency and affect plant growth, although leaf yellowing was apparent at 3.0 kg/m^3 in many species. Media and leaf tissue samples were taken at transplanting from all species and at maturity from the species *Petunia* which confirmed the phosphate levels corresponded with the applied phosphate treatments. All samples were unreplicated due to the limited plant material available. As such no firm conclusions can be drawn from these analyses other than the observations given.

The use of water 'stress' to control plant height proved again to be successful and confirmed results found in 1993. All plant species responded with a reduction in their growth, particularly for the more tender species; *Petunia* and *Impatiens*, whose growth was limited without a dramatic reduction in plant quality. With other species; Marigold, *Lobelia* and *Mesembryanthemum*, growth under the 'dry' regime was reduced to an extent which limited plant quality and the perceived value by the customer. The practicality of applying a 'dry' watering regime to the precision entailed in this trial would be difficult. Although great savings in water use were made this was due to careful crop monitoring and the ability to apply irrigation at a precise time as the plant reached wilting point. Any delay in water application could seriously affect plant growth, and in a worst case plant death could result, care therefore should be exercised with this technique. Nevertheless, the use of water 'stress' produced significant reductions in plant growth, and there is the possibility to apply irrigation earlier, prior to complete plant wilting and still produce a height control response. The 'dry' watering regime further emphasised the phosphate treatments, and plant growth was reduced at levels below and above 1.0 kg/m^3. This was apparent in all species.

Further work will be necessary, and is planned for the 1995 season, to examine levels of single superphosphate below 1.0 kg/m^3. This will provide further information on the use of restricted phosphate and aim to select a level of phosphate which will provide sufficient height control in the plug stage, without inhibiting plant growth in the final container to produce a high quality, marketable plant. In addition, the use of high phosphate liquid feeds may be a method which can be applied in the plug stage prior to transplanting to boost plant growth. This will be advantageous at very low phosphate levels where root development is not sufficient to allow rapid and clean removal of plants from the plug tray. Liquid feeding with the inclusion of phosphate may stimulate root growth prior to transplanting.

Since the use of water 'stress' can be used to control plant height the techniques and practicalities of application need to be further examined and measures adopted which can be easily implemented by growers.

CONCLUSIONS

- The use of restricted phosphate can be used as a cultural tool by growers to control plant height in the plug and growing on stage for a wide range of bedding plant species.

- Zero phosphate will afford the greatest control of plant growth but it is recommended to use a level of 0.5 kg/m^3 as a general guide for all species. At this level plant growth can be limited in the plug stage to avoid excessive 'stretching' and plants will reach a marketable size when transplanted.

- The use of a 'dry' watering regime has the potential to be used to control plant height, but no easy method is yet available to growers to monitor and control irrigation effectively on bedding plants.

FUTURE PROGRAMME

Further evaluation of the level of single superphosphate is required to determine rates which will control plant height in the plug module without affecting or delaying subsequent growth and sale. The use of applied high phosphate liquid feeds has not been assessed in the context of this trial, but may be a practical measure which can be used in the future to 'switch' plant growth back on after limiting plant growth in the plug module. These two areas need to be examined in conjunction with each other.

The use of 'water stress' should receive further attention, especially as new electronic instruments become available which could be linked directly to an environmental computer in a glasshouse. Therefore, it is important information is gathered on plant responses to different irrigation regimes with a view to applying this knowledge when practical methods of application are available.

It is proposed for 1995 to examine levels of single superphosphate from zero up to 1.2 kg/m^3 at intervals of 0.3 kg/m^3 and to assess the use of high phosphate feeds applied prior to transplanting to boost growth and overcome any 'check' experienced at restricted phosphate levels. Further evaluation on the use of a 'dry' watering regime will also be conducted.

APPENDICES

COMMERCIAL - IN CONFIDENCE

N

Bedding Plants : Investigation of cultural methods for controlling height

12°C

Standard regime	Sp. 1 Alyssum					Sp. 2 Lobelia					Sp. 3 Mesembryanthemum					Sp. 4 Pansy				
Rep I	3	1	0.5	2	0	0	1	3	0.5	2	0	1	0.5	3	2	0	1	3	2	0.5
Rep II	2	1	0	0.5	3	2	0	0.5	1	3	3	2	0	0.5	1	1	3	0.5	0	2

"Dry" regime																				
Rep I	1	0	2	3	0.5	1	0.5	0	2	3	2	1	3	0.5	0	0.5	0	2	1	3
Rep II	3	0.5	0	1	2	0.5	3	2	1	0	1	0	2	3	0.5	0	1	3	2	0.5

COMMERCIAL – IN CONFIDENCE

N

Bedding Plants : Investigation of cultural methods for controlling height

16°C

	Standard regime	Sp. 1 Impatiens				Sp. 2 Marigold					Sp. 3 Petunia					Sp. 4 Salvia				
Rep I	2	0	0.5	1	3	0.5	1	0	2	3	3	2	0	0.5	1	2	0.5	3	1	0
Rep II	1	0	2	3	0.5	0	0.5	3	1	2	2	3	1	0.5	0	1	0	0.5	3	2

	"Dry" regime																			
Rep I	3	2	1	0	0.5	1	3	2	0	0.5	1	0	2	3	0.5	0	0.5	3	1	2
Rep II	1	0.5	0	2	3	3	0.5	0	1	2	3	2	1	0.5	0	1	3	2	0	0.5

APPENDIX II

Table 1: Media Analysis at Sowing

		Treatment Level of Single Superphosphate (kg/m^3)				
		0	**0.5**	**1.0**	**2.0**	**3.0**
pH		6.0	5.9	5.9	5.9	5.8
Conductivity	μs	269	390	435	535	620
Phosphorus	(mg/l)	0	37	70	131	180
Potassium	(mg/l)	184	237	247	247	231
Nitrate (N)	(mg/l)	154	182	171	159	152
Ammonium (N)	(mg/l)	74	103	102	101	94
Magnesium	(mg/l)	16	36	44	63	73

APPENDIX III

Crop Diary

Table 2

Culture	Marigold	*Impatiens*	*Petunia*	*Salvia*	Alyssum	*Mesembryanthemum*	*Lobelia*	Pansy
Sown	08 Mar	14 Feb	13 Feb	13 Feb	15 Feb	12 Feb	16 Feb	12 Feb
Seed No/plug	1	1	1	1	4	1	6	1
Vermiculite covering	Medium	Medium	None	Medium	None	Fine	None	Fine
Emergence	11 Mar	21 Feb	20 Feb	19 Feb	17 Feb	19 Feb	23 Feb	19 Feb
Transferred from 'H' to 'K'	21 Mar	10 Mar	14 Mar	10 Mar	10 Mar	10 Mar	10 Mar	10 Mar
Started Feeding Plugs (75ppm N)	21 Mar	10 Mar	14 Mar	10 Mar	10 Mar	10 Mar	10 Mar	10 Mar
Transplanted	06 Apr	24 Mar	30 Mar	25 Mar	23 Mar	13 Apr	14 Apr	08 Apr
Feed (150ppm N)	10 Apr	31 Mar	09 Apr	31 Mar	31 Mar	19 Apr	21 Apr	11 Apr
Commenced watering regime	10 Apr	09 Apr	09 Apr	08 Apr	09 Apr	19 Apr	21 Apr	11 Apr
10°C vent 12°C	26 Apr	26 Apr	26 Apr	26 Apr	26 Apr	26 Apr	26 Apr	26 Apr
Benlate 0.5g/l	-	-	-	-	-	-	-	29 Mar
Repulse 2.2g/l	-	-	-	-	-	-	-	08 Apr
Planted Out	30 May	30 May	27 May	30 May	27 May	18 May	18 May	16 May

COMMERCIAL – IN CONFIDENCE

APPENDIX IV

Plant Growth Assessments at Transplanting

Table 3: **Pansy 'F1 Turbo Blue-White Bicolour'**

(figures are a mean of 20 plants)

Treatment Level of Phosphate (kg/m³)	Mean Height (mm)	Mean Quality Score 1 to 3 (3=best)	Mean Vigour Score 1 to 3 (3=greatest vigour)	Mean Rooting Score 1 to 4 (4=excellent)	Mean Leaf Area (cm²)	Mean Fresh Weight (g)	% Dry Matter Content
0	21.0	1.0	1.05	2.0	3.4	0.18	18.15
0.5	49.8	2.5	2.36	3.0	6.9	0.58	15.18
1.0	46.6	2.0	2.20	4.0	6.1	0.57	14.77
2.0	36.0	1.5	2.01	3.0	5.1	0.42	16.16
3.0	48.7	2.0	2.41	3.0	5.4	0.54	13.00
SED (d.f. = 8) =	*3.5*	*0.3*	*0.10*	-	-	-	-
LSD (5%) =	*8.1*	*0.7*	*0.24*	-	-	-	-

Table 4: ***Mesembryanthemum criniflorum* 'Magic Carpet Mixed'**

(figures are a mean of 20 plants)

Treatment Level of Phosphate (kg/m³)	Mean Height (mm)	Mean Quality Score 1 to 3 (3=best)	Mean Vigour Score 1 to 3 (3=greatest vigour)	Mean Rooting Score 1 to 4 (4=excellent)	Mean Leaf Area (cm²)	Mean Fresh Weight (g)	% Dry Matter Content
0	31.3	1.0	1.34	1.0	3.8	0.90	5.89
0.5	59.2	3.0	2.14	4.0	6.5	1.77	5.37
1.0	53.4	2.0	1.95	4.0	5.9	1.60	4.62
2.0	64.9	2.0	2.06	4.0	4.8	1.58	4.76
3.0	62.1	2.0	2.04	2.0	5.0	1.49	5.21
SED (d.f. = 8) =	*4.2*	*N/S*	*0.11*	-	-	-	-
LSD (5%) =	*9.7*		*0.24*	-	-	-	-

APPENDIX IV

Plant Growth Assessments at Transplanting

Table 5: **Alyssum 'Snowdrift'**

(figures are a mean of 20 plants)

Treatment Level of Phosphate (kg/m³)	Mean Height (mm)	Mean Quality Score 1 to 3 (3=best)	Mean Vigour Score 1 to 3 (3=greatest vigour)	Mean Rooting Score 1 to 4 (4=excellent)	Mean Leaf Area (cm²)	Mean Fresh Weight (g)	% Dry Matter Content
0	26.4	1.0	1.86	1.0	1.8	0.18	11.57
0.5	45.1	2.0	2.85	3.0	4.4	0.52	9.83
1.0	40.6	2.5	2.67	3.0	2.8	0.38	11.14
2.0	45.7	3.0	2.97	4.0	4.2	0.56	9.48
3.0	40.7	1.0	2.77	2.0	4.1	0.49	10.23
SED (d.f. = 8) =	*2.1*	*0.2*	*0.15*	-	-	-	-
LSD (5%) =	*4.9*	*0.5*	*0.34*	-	-	-	-

Table 6: ***Salvia splendens* 'Vanguard'**

(figures are a mean of 20 plants)

Treatment Level of Phosphate (kg/m³)	Mean Height (mm)	Mean Quality Score 1 to 3 (3=best)	Mean Vigour Score 1 to 3 (3=greatest vigour)	Mean Rooting Score 1 to 4 (4=excellent)	Mean Leaf Area (cm²)	Mean Fresh Weight (g)	% Dry Matter Content
0	27.9	1.0	1.82	1.0	6.2	0.31	11.93
0.5	55.0	2.5	2.41	2.0	8.0	0.57	12.80
1.0	61.5	2.5	2.37	3.0	7.2	0.58	11.74
2.0	64.9	3.0	2.76	4.0	8.0	0.59	10.97
3.0	53.2	2.0	2.57	3.0	9.0	0.57	11.81
SED (d.f. = 8) =	*2.7*	*0.3*	*0.09*	-	-	-	-
LSD (5%) =	*5.4*	*0.6*	*0.22*	-	-	-	-

APPENDIX IV

Plant Growth Assessments at Transplanting

Table 7: **Marigold 'Aurora Fire'**

(figures are a mean of 20 plants)

Treatment Level of Phosphate (kg/m³)	Mean Height (mm)	Mean Quality Score 1 to 3 (3=best)	Mean Vigour Score 1 to 3 (3=greatest vigour)	Mean Rooting Score 1 to 4 (4=excellent)	Mean Leaf Area (cm²)	Mean Fresh Weight (g)	% Dry Matter Content
0	33.6	2.0	1.51	1.0	1.8	0.19	15.64
0.5	42.7	2.0	2.14	3.0	4.3	0.57	11.20
1.0	46.5	2.0	2.25	4.0	5.1	0.58	11.09
2.0	44.5	2.0	2.14	4.0	4.9	0.53	10.14
3.0	47.6	3.0	2.42	4.0	5.65	0.62	10.65
SED (d.f. = 8) =	*1.1*	*N/S*	*0.15*	-	-	-	-
LSD (5%) =	*2.5*		*0.34*	-	-	-	-

Table 8: ***Lobelia erinus* 'Crystal Palace'**

(figures are a mean of 20 plants)

Treatment Level of Phosphate (kg/m³)	Mean Height (mm)	Mean Quality Score 1 to 3 (3=best)	Mean Vigour Score 1 to 3 (3=greatest vigour)	Mean Rooting Score 1 to 4 (4=excellent)	Mean Leaf Area (cm²)	Mean Fresh Weight (g)	% Dry Matter Content
0	15.3	1.0	1.01	1.0	2.65	0.18	18.13
0.5	50.4	2.0	2.06	4.0	5.80	0.58	11.25
1.0	44.3	3.0	1.92	4.0	5.15	0.58	11.45
2.0	52.8	2.0	2.02	3.0	5.85	0.60	10.5
3.0	50.0	2.5	2.04	2.0	5.30	0.56	10.12
SED (d.f. = 8) =	*2.7*	*0.2*	*0.05*	-	-	-	-
LSD (5%) =	*6.1*	*0.5*	*0.13*	-	-	-	-

APPENDIX IV

Plant Growth Assessments at Transplanting

Table 9: ***Petunia* hybr. 'F1 Express Blue Star'**

(figures are a mean of 20 plants)

Treatment Level of Phosphate (kg/m³)	Mean Height (mm)	Mean Quality Score 1 to 3 (3=best)	Mean Vigour Score 1 to 3 (3=greatest vigour)	Mean Rooting Score 1 to 4 (4=excellent)	Mean Leaf Area (cm²)	Mean Fresh Weight (g)	% Dry Matter Content
0	19.8	1.0	1.64	1.0	3.1	0.25	7.34
0.5	41.0	3.0	2.60	4.0	6.7	0.99	6.84
1.0	33.3	2.5	2.05	3.0	5.2	0.58	8.57
2.0	28.1	2.0	2.09	3.0	5.45	0.50	9.01
3.0	23.9	2.0	1.71	3.0	5.1	0.56	9.12
SED (d.f. = 8) =	*2.1*	*0.2*	*0.16*	-	-	-	-
LSD (5%) =	*4.7*	*0.5*	*0.36*	-	-	-	-

Table 10: ***Impatiens walleriana* 'F1 Accent Salmon'**

(figures are a mean of 20 plants)

Treatment Level of Phosphate (kg/m³)	Mean Height (mm)	Mean Quality Score 1 to 3 (3=best)	Mean Vigour Score 1 to 3 (3=greatest vigour)	Mean Rooting Score 1 to 4 (4=excellent)	Mean Leaf Area (cm²)	Mean Fresh Weight (g)	% Dry Matter Content
0	15.1	1.0	1.18	1.0	2.45	0.21	7.39
0.5	35.8	3.0	2.26	3.0	6.1	0.51	6.35
1.0	36.5	2.0	2.07	4.0	4.4	0.49	6.45
2.0	48.7	2.0	2.64	2.0	5.75	0.62	5.9
3.0	32.1	2.0	2.10	2.0	4.55	0.48	6.97
SED (d.f. = 8) =	*3.1*	*N/S*	*0.08*	-	-	-	-
LSD (5%) =	*7.1*		*0.20*	-	-	-	-

APPENDIX V

Foliage Analysis at Transplanting

Table 11: **Pansy 'F1 Turbo Blue-White Bicolour'**

		Treatment Level of Single Superphosphate (kg/m^3)				
		0	**0.5**	**1.0**	**2.0**	**3.0**
Nitrogen	(%DM)	2.47	2.71	2.78	3.72	2.44
Phosphate-P	(%DM)	0.12	0.26	0.37	0.70	0.43
Potassium	(%DM)	3.20	3.23	3.42	4.11	3.15
Magnesium	(%DM)	0.33	0.42	0.46	0.54	0.39
Calcium	(%DM)	0.78	0.76	0.92	1.11	0.85
Copper	(mg/kg DM)	3.2	3.8	3.4	1.2	3.4
Manganese	(mg/kg DM)	267	192	162	95	171

Table 12: ***Mesembryanthemum criniflorum*** **'Magic Carpet Mixed'**

		Treatment Level of Single Superphosphate (kg/m^3)				
		0	**0.5**	**1.0**	**2.0**	**3.0**
Nitrogen	(%DM)	3.56	2.71	3.29	3.28	3.18
Phosphate-P	(%DM)	0.10	0.20	0.30	0.59	0.82
Potassium	(%DM)	7.16	5.09	5.33	5.18	5.47
Magnesium	(%DM)	0.96	1.30	1.12	1.21	1.26
Calcium	(%DM)	1.77	2.11	2.16	2.53	2.54
Copper	(mg/kg DM)	20.7	15.2	14.0	15.3	3.0
Manganese	(mg/kg DM)	254	201	206	224	85

APPENDIX V

Foliage Analysis at Transplanting

Table 13: **Alyssum 'Snowdrift'**

		Treatment Level of Single Superphosphate (kg/m³)				
		0	**0.5**	**1.0**	**2.0**	**3.0**
Nitrogen	(%DM)	4.02	3.01	2.88	2.78	2.83
Phosphate-P	(%DM)	0.20	0.34	0.45	0.64	0.65
Potassium	(%DM)	3.48	3.79	3.36	3.59	3.35
Magnesium	(%DM)	0.44	0.39	0.31	0.36	0.35
Calcium	(%DM)	1.98	2.05	2.16	2.17	2.81
Copper	(mg/kg DM)	14.4	10.0	8.0	6.4	2.2
Manganese	(mg/kg DM)	118	93	76	73	62

Table 14: ***Salvia splendens* 'Vanguard'**

		Treatment Level of Single Superphosphate (kg/m³)				
		0	**0.5**	**1.0**	**2.0**	**3.0**
Nitrogen	(%DM)	3.09	2.53	2.11	2.40	2.27
Phosphate-P	(%DM)	0.20	0.33	0.39	0.58	0.62
Potassium	(%DM)	4.15	3.09	2.77	3.15	2.89
Magnesium	(%DM)	0.46	0.60	0.67	0.66	0.69
Calcium	(%DM)	1.65	1.56	1.53	1.57	1.55
Copper	(mg/kg DM)	6.8	7.6	7.0	7.0	2.6
Manganese	(mg/kg DM)	159	119	120	113	62

APPENDIX V

Foliage Analysis at Transplanting

Table 15: **Marigold 'Aurora Fire'**

		Treatment Level of Single Superphosphate (kg/m^3)				
		0	**0.5**	**1.0**	**2.0**	**3.0**
Nitrogen	(%DM)	3.04	3.28	3.44	3.28	3.85
Phosphate-P	(%DM)	0.11	0.30	0.38	0.52	0.86
Potassium	(%DM)	3.13	4.07	3.68	3.03	3.18
Magnesium	(%DM)	0.50	0.60	0.65	0.60	0.75
Calcium	(%DM)	1.47	1.79	1.81	1.84	2.08
Copper	(mg/kg DM)	12.3	11.6	10.6	10.0	2.4
Manganese	(mg/kg DM)	199	152	158	160	96

Table 16: ***Lobelia erinus*** **'Crystal Palace'**

		Treatment Level of Single Superphosphate (kg/m^3)				
		0	**0.5**	**1.0**	**2.0**	**3.0**
Nitrogen	(%DM)	3.61	3.42	3.15	3.52	3.10
Phosphate-P	(%DM)	0.08	0.18	0.28	0.55	0.68
Potassium	(%DM)	2.87	3.96	3.51	4.12	3.97
Magnesium	(%DM)	0.22	0.31	0.28	0.29	0.27
Calcium	(%DM)	1.13	1.43	1.73	1.81	1.91
Copper	(mg/kg DM)	10.8	10.0	9.2	10.4	3.6
Manganese	(mg/kg DM)	94	104	95	107	47

APPENDIX V

Foliage Analysis at Transplanting

Table 17: *Petunia* hybr. 'F1 Express Blue Star'

		Treatment Level of Single Superphosphate (kg/m^3)				
		0	**0.5**	**1.0**	**2.0**	**3.0**
Nitrogen	(%DM)	2.75	3.29	2.92	2.64	2.69
Phosphate-P	(%DM)	0.11	0.29	0.35	0.52	0.64
Potassium	(%DM)	3.97	3.45	3.44	3.46	3.55
Magnesium	(%DM)	0.25	0.32	0.27	0.24	0.27
Calcium	(%DM)	1.15	1.36	1.70	1.61	1.70
Copper	(mg/kg DM)	12.6	8.1	9.9	7.8	2.7
Manganese	(mg/kg DM)	112	107	105	84	56

Table 18: *Impatiens walleriana* 'F1 Accent Salmon'

		Treatment Level of Single Superphosphate (kg/m^3)				
		0	**0.5**	**1.0**	**2.0**	**3.0**
Nitrogen	(%DM)	3.54	2.76	2.00	3.09	2.27
Phosphate-P	(%DM)	0.24	0.43	0.39	0.89	0.80
Potassium	(%DM)	2.61	2.30	2.00	2.43	2.36
Magnesium	(%DM)	0.60	0.54	0.43	0.52	0.42
Calcium	(%DM)	2.52	2.91	2.94	3.25	3.22
Copper	(mg/kg DM)	8.4	10.0	8.4	9.6	3.8
Manganese	(mg/kg DM)	182	172	169	177	86

APPENDIX VI

Plant Growth Assessments at Maturity

Table 19: **Pansy 'F1 Turbo Blue-White Bicolour'**

(figures are a mean of 12 plants)

Treatment Level of Phosphate (kg/m^3)	Mean Height (mm)		Mean Quality Score 1 to 3 (3=best)		Mean Flower Score 1 to 3 (3=most flowers)		Mean Pack Weight (kg)	
	Standard	Dry	Standard	Dry	Standard	Dry	Standard	Dry
0	15.0	13.4	1.0	1.0	1.0	1.0	1.07	0.82
0.5	107.5	65.2	2.0	2.0	2.0	1.5	1.48	0.84
1.0	126.7	81.7	3.0	2.0	3.0	2.0	1.91	0.87
2.0	101.7	82.5	2.0	2.0	2.0	2.0	1.78	0.86
3.0	118.8	88.8	3.0	2.0	3.0	2.0	1.72	1.02
SED (d.f. = 8) =	*8.7*		*N/S*		*0.2*		*0.08*	
LSD (5%) =	*20.0*				*0.5*		*0.19*	

Table 20: ***Mesembryanthemum criniflorum* 'Magic Carpet Mixed'**

(figures are a mean of 12 plants)

Treatment Level of Phosphate (kg/m^3)	Mean Height (mm)		Mean Quality Score 1 to 3 (3=best)		Mean Flower Score 1 to 3 (3=most flowers)		Mean Pack Weight (kg)	
	Standard	Dry	Standard	Dry	Standard	Dry	Standard	Dry
0	20.8	19.2	1.0	1.0	-	-	0.87	0.83
0.5	88.2	50.6	2.0	2.0	-	-	0.94	1.00
1.0	102.7	68.5	3.0	2.0	-	-	1.03	0.98
2.0	117.3	62.7	3.0	2.0	-	-	1.06	0.96
3.0	101.5	54.4	3.0	2.0	-	-	1.14	0.97
SED (d.f. = 8) =	*11.83*		*N/S*				*0.08*	
LSD (5%) =	*27.28*						*0.035*	

APPENDIX VI

Plant Growth Assessments at Maturity

Table 21: **Alyssum 'Snowdrift'**

(figures are a mean of 12 plants)

Treatment Level of Phosphate (kg/m³)	Mean Height (mm)		Mean Quality Score 1 to 3 (3=best)		Mean Flower Score 1 to 3 (3=most flowers)		Mean Pack Weight (kg)	
	Standard	Dry	Standard	Dry	Standard	Dry	Standard	Dry
0	27.7	24.8	1.0	1.0	1.0	1.0	1.09	0.80
0.5	81.6	62.5	2.0	1.0	2.5	2.0	1.14	1.11
1.0	92.9	77.0	2.5	2.0	3.0	2.0	1.28	1.12
2.0	94.3	64.7	3.0	2.0	3.0	2.0	1.43	0.96
3.0	88.2	66.4	2.0	1.0	2.0	2.0	1.28	1.09
SED (d.f. = 8) =	*5.1*		*0.2*		*0.2*		*0.16*	
LSD (5%) =	*11.7*		*0.5*		*0.5*		*0.37*	

Table 22: ***Salvia splendens* 'Vanguard'**

(figures are a mean of 12 plants)

Treatment Level of Phosphate (kg/m³)	Mean Height (mm)		Mean Quality Score 1 to 3 (3=best)		Mean Flower Score 1 to 3 (3=most flowers)		Mean Pack Weight (kg)	
	Standard	Dry	Standard	Dry	Standard	Dry	Standard	Dry
0	52.7	40.8	1.0	1.0	1.0	1.0	0.92	0.67
0.5	150.6	87.9	3.0	1.0	2.0	1.0	1.02	0.80
1.0	152.3	107.3	3.0	2.0	2.0	1.5	0.93	0.74
2.0	174.0	104.8	3.0	1.5	2.5	1.0	1.09	0.76
3.0	153.5	100.2	3.0	2.0	2.5	2.5	1.09	0.80
SED (d.f. = 8) =	*9.7*		*0.2*		*0.4*		*0.056*	
LSD (5%) =	*22.3*		*0.5*		*1.0*		*0.13*	

APPENDIX VI

Plant Growth Assessments at Maturity

Table 23: **Marigold 'Aurora Fire'**

(figures are a mean of 12 plants)

Treatment Level of Phosphate (kg/m³)	Mean Height (mm)		Mean Quality Score 1 to 3 (3=best)		Mean Flower Score 1 to 3 (3=most flowers)		Mean Pack Weight (kg)	
	Standard	Dry	Standard	Dry	Standard	Dry	Standard	Dry
0	88.3	58.7	1.0	1.0	1.0	1.0	0.98	0.71
0.5	110.6	94.4	2.0	2.0	2.0	2.5	1.03	0.71
1.0	123.5	101.7	3.0	2.0	2.5	2.5	1.30	0.73
2.0	122.5	98.8	3.0	2.0	2.5	2.5	1.04	0.65
3.0	116.5	96.0	3.0	2.0	2.5	2.0	1.07	0.68
SED (d.f. = 8) =	*5.8*		*N/S*		*0.6*		*0.1*	
LSD (5%) =	*13.3*				*1.4*		*0.2*	

Table 24: ***Lobelia erinus* 'Crystal Palace'**

(figures are a mean of 12 plants)

Treatment Level of Phosphate (kg/m³)	Mean Height (mm)		Mean Quality Score 1 to 3 (3=best)		Mean Flower Score 1 to 3 (3=most flowers)		Mean Pack Weight (kg)	
	Standard	Dry	Standard	Dry	Standard	Dry	Standard	Dry
0	15.8	13.8	1.0	1.0	1.0	1.0	0.99	0.85
0.5	129.6	87.5	2.5	2.0	2.0	2.0	1.41	0.77
1.0	130.4	98.1	3.0	2.0	1.5	2.0	1.61	0.75
2.0	128.3	97.7	2.5	2.0	2.5	1.0	1.24	0.75
3.0	115.6	90.2	2.0	1.0	1.0	2.0	1.33	0.83
SED (d.f. = 8) =	*5.32*		*0.35*		*0.76*		*0.08*	
LSD (5%) =	*12.27*		*0.81*		*1.75*		*0.18*	

APPENDIX VI

Plant Growth Assessments at Maturity

Table 25: ***Petunia* hybr. 'F1 Express Blue Star'**

(figures are a mean of 12 plants)

Treatment Level of Phosphate (kg/m³)	Mean Height (mm)		Mean Quality Score 1 to 3 (3=best)		Mean Flower Score 1 to 3 (3=most flowers)		Mean Pack Weight (kg)	
	Standard	Dry	Standard	Dry	Standard	Dry	Standard	Dry
0	14.6	12.1	1.0	1.0	1.0	1.0	0.88	0.90
0.5	85.3	57.2	1.5	1.0	2.0	1.0	0.99	1.02
1.0	96.1	47.5	2.0	1.0	1.0	1.0	0.84	1.05
2.0	117.3	54.0	3.0	1.5	1.0	1.0	0.99	1.09
3.0	108.0	40.5	3.0	1.5	1.0	1.0	1.15	1.10
SED (d.f. = 8) =	*6.3*		*0.3*		*N/S*		*0.08*	
LSD (5%) =	*14.6*		*0.8*				*0.18*	

Table 26: ***Impatiens walleriana* 'F1 Accent Salmon'**

(figures are a mean of 12 plants)

Treatment Level of Phosphate (kg/m³)	Mean Height (mm)		Mean Quality Score 1 to 3 (3=best)		Mean Flower Score 1 to 3 (3=most flowers)		Mean Pack Weight (kg)	
	Standard	Dry	Standard	Dry	Standard	Dry	Standard	Dry
0	32.9	28.3	1.0	1.0	1.0	1.0	0.90	0.73
0.5	103.5	75.6	2.0	1.0	2.0	1.5	0.97	0.75
1.0	122.9	94.4	3.0	1.5	2.0	2.0	1.06	0.81
2.0	113.3	87.9	2.5	2.0	3.0	2.0	1.16	0.85
3.0	99.4	61.9	2.5	1.0	2.0	1.5	1.22	1.02
SED (d.f. = 8) =	*9.7*		*0.3*		*0.3*		*0.07*	
LSD (5%) =	*22.4*		*0.8*		*0.8*		*0.17*	

APPENDIX VII

Growing Media Analysis at Maturity

Table 27: *Petunia* hybr. 'F1 Express Blue Star'

Standard Watering Regime

		Treatment Level of Single Superphosphate (kg/m³)				
		0	**0.5**	**1.0**	**2.0**	**3.0**
pH Value		5.13	5.29	5.45	5.42	5.24
Conductivity	µs	349	89	137	198	289
Ammonia-N	mg/l	56.4	4.8	3.6	2.4	9.0
Nitrate-N	mg/l	209.4	18.6	19.2	15.6	12.6
Total-N	mg/l	265.8	23.4	22.8	18.0	21.6
Phosphorus-P	mg/l	2.4	4.8	7.8	22.2	54.6
Potassium	mg/l	240.0	42.0	24.0	18.0	24.0
Calcium	mg/l	59.4	23.3	75.0	144.6	231.0
Magnesium	mg/l	25.8	7.8	16.8	25.2	40.2
Sulphate	mg/l	73.8	117.6	234.0	431.4	739.2
Sodium	mg/l	71.4	46.8	43.8	31.8	40.2
Chloride	mg/l	61.2	12.6	10.2	7.8	9.6
Boron	mg/l	0.36	0.12	0.06	<0.06	<0.06
Copper	mg/l	<0.06	<0.06	<0.06	<0.06	<0.06
Manganese	mg/l	0.24	<0.06	0.06	0.06	0.06
Zinc	mg/l	0.18	0.18	0.06	0.12	0.24
Iron	mg/l	0.24	0.54	0.30	0.18	0.30
Density	kg/m³	352	333	386	385	383
Dry Matter	%	33.0	34.8	25.0	25.8	26.3
Dry Density	kg/m³	116.2	115.9	96.5	99.3	100.7

APPENDIX VII

Growing Media Analysis at Maturity

Table 28: *Petunia* hybr. 'F1 Express Blue Star'

'Dry' Watering Regime

		Treatment Level of Single Superphosphate (kg/m³)				
		0	0.5	1.0	2.0	3.0
pH Value		5.18	5.35	5.42	5.39	5.26
Conductivity	µs	331	152	161	247	366
Ammonia-N	mg/l	60.6	16.8	4.8	6.6	12.6
Nitrate-N	mg/l	195.6	52.2	23.4	16.2	15.6
Total-N	mg/l	256.2	69.0	28.2	22.8	28.2
Phosphorus-P	mg/l	2.4	6.6	11.4	48.6	94.2
Potassium	mg/l	210.0	78.0	42.0	30.0	36.0
Calcium	mg/l	52.8	36.6	85.8	172.2	303.6
Magnesium	mg/l	23.4	13.2	19.8	36.6	53.4
Sulphate	mg/l	69.0	151.2	289.8	567.6	1001.4
Sodium	mg/l	60.6	45.0	41.4	41.4	43.8
Chloride	mg/l	52.8	22.2	12.6	10.8	12.6
Boron	mg/l	0.18	<0.06	<0.06	<0.06	<0.06
Copper	mg/l	<0.06	<0.06	<0.06	<0.06	<0.06
Manganese	mg/l	0.18	<0.06	0.06	0.06	<0.06
Zinc	mg/l	0.18	0.18	0.12	0.12	0.12
Iron	mg/l	0.18	0.30	0.24	0.24	0.36
Density	kg/m³	334	389	441	447	386
Dry Matter	%	38.8	30.0	23.5	22.0	26.9
Dry Density	kg/m³	129.6	116.7	103.6	98.3	103.8

Contract No: PC/86

TERMS AND CONDITIONS

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

Signed for the Contractor(s)

Signature.....

Position..Commercial and Marketing Manager H&I

Date.....16/2/94.....

Signed for the Contractor(s)

Signature.....

Position.....

Date.....

Signed for the Council

Signature.....

Position.....CHIEF EXECUTIVE

Date.....23.12.93.....

APPENDIX VII

Foliage Analysis at Maturity

Table 29: *Petunia* hybr. 'F1 Express Blue Star'
Standard Watering Regime

		Treatment Level of Single Superphosphate (kg/m³)				
		0	**0.5**	**1.0**	**2.0**	**3.0**
Nitrogen	(% DM)	6.25	3.88	3.44	3.34	3.92
Phosphorus	(% DM)	0.05	0.37	0.50	0.96	1.17
Potassium	(% DM)	3.02	4.14	3.52	3.77	3.89
Magnesium	(% DM)	0.50	0.40	0.36	0.42	0.44
Calcium	(% DM)	1.83	1.71	1.63	1.81	2.09
Manganese	(mg/kg DM)	119	146	124	109	68
Copper	(mg/kg DM)	18.5	10.4	7.2	6.6	3.2

Table 30: *Petunia* hybr. 'F1 Express Blue Star'
'Dry' Watering Regime

		Treatment Level of Single Superphosphate (kg/m³)				
		0	**0.5**	**1.0**	**2.0**	**3.0**
Nitrogen	(% DM)	5.94	4.84	5.03	4.76	4.90
Phosphorus	(% DM)	0.04	0.57	0.84	1.16	1.34
Potassium	(% DM)	3.21	5.71	4.83	5.03	4.97
Magnesium	(% DM)	0.51	0.48	0.46	0.43	0.43
Calcium	(% DM)	1.83	1.92	2.14	2.12	2.12
Manganese	(mg/kg DM)	128	159	150	145	84
Copper	(mg/kg DM)	14.7	11.4	9.4	8.2	2.6

APPENDIX VIII

Watering Regime Records

(Total amount of water (in litres) applied per 0.74m² (9 Double - six trays) from transplanting until maturity)

Table 31: Pansy 'F1 Turbo Blue-White Bicolour'

	Treatment Level of SuperPhosphate (kg/m³)					
	0	**0.5**	**1.0**	**2.0**	**3.0**	**Mean**
Standard (litres)	2.15	1.66	2.38	1.48	3.98	2.33
Dry (litres)	0.80	0.36	0.32	0.19	0.18	0.37

Table 32: *Mesembryanthemum criniflorum* 'Magic Carpet Mixed'

	Treatment Level of Single Superphosphate (kg/m³)					
	0	**0.5**	**1.0**	**2.0**	**3.0**	**Mean**
Standard (litres)	2.47	1.69	1.58	2.79	1.35	1.98
Dry (litres)	0.40	1.00	N/A	0.20	0.66	0.56

Table 33: Alyssum 'Snowdrift'

	Treatment Level of Single Superphosphate (kg/m³)					
	0	**0.5**	**1.0**	**2.0**	**3.0**	**Mean**
Standard (litres)	4.75	4.13	2.06	1.45	0.49	2.58
Dry (litres)	1.68	1.03	1.05	1.64	0.14	1.11

APPENDIX VIII

Watering Regime Records

(Total amount of water (in litres) applied per 0.74m² (9 Double - six trays) from transplanting until maturity)

Table 34: *Salvia splendens* 'Vanguard'

	Treatment Level of Single Superphosphate (kg/m³)					
	0	**0.5**	**1.0**	**2.0**	**3.0**	**Mean**
Standard (litres)	3.88	5.76	4.97	1.00	2.86	3.69
Dry (litres)	1.80	1.17	1.24	1.33	0.84	1.28

Table 35: Marigold 'Aurora Fire'

	Treatment Level of Single Superphosphate (kg/m³)					
	0	**0.5**	**1.0**	**2.0**	**3.0**	**Mean**
Standard (litres)	3.2	1.65	1.80	2.40	1.84	2.18
Dry (litres)	1.84	0.36	1.00	0.90	1.10	1.04

Table 36: *Lobelia erinus* 'Crystal Palace'

	Treatment Level of Single Superphosphate (kg/m³)					
	0	**0.5**	**1.0**	**2.0**	**3.0**	**Mean**
Standard (litres)	2.96	1.96	0.93	2.33	1.89	2.01
Dry (litres)	1.59	1.03	0.22	0.23	0.46	0.71

APPENDIX VIII

Watering Regime Records

(Total amount of water (in litres) applied per 0.74m² (9 Double - six trays) from transplanting until maturity)

Table 37: *Petunia* hybr. 'F1 Express Blue Star'

	Treatment Level of Single Superphosphate (kg/m³)					
	0	**0.5**	**1.0**	**2.0**	**3.0**	**Mean**
Standard (litres)	1.90	4.10	3.80	1.50	2.90	2.84
Dry (litres)	0.80	0.89	1.50	0.80	0.30	0.86

Table 38: *Impatiens walleriana* 'F1 Accent Salmon'

	Treatment Level of Single Superphosphate (kg/m³)					
	0	**0.5**	**1.0**	**2.0**	**3.0**	**Mean**
Standard (litres)	3.60	4.10	3.10	2.10	2.10	3.00
Dry (litres)	1.70	1.30	0.40	0.80	0.40	0.92

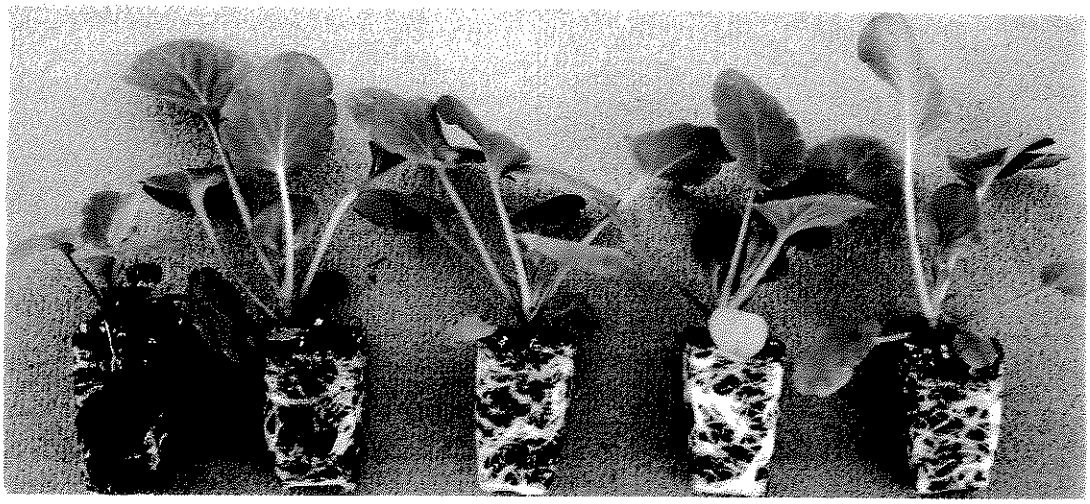
APPENDIX IX

Plate 1: Comparison of phosphate treatments at transplanting

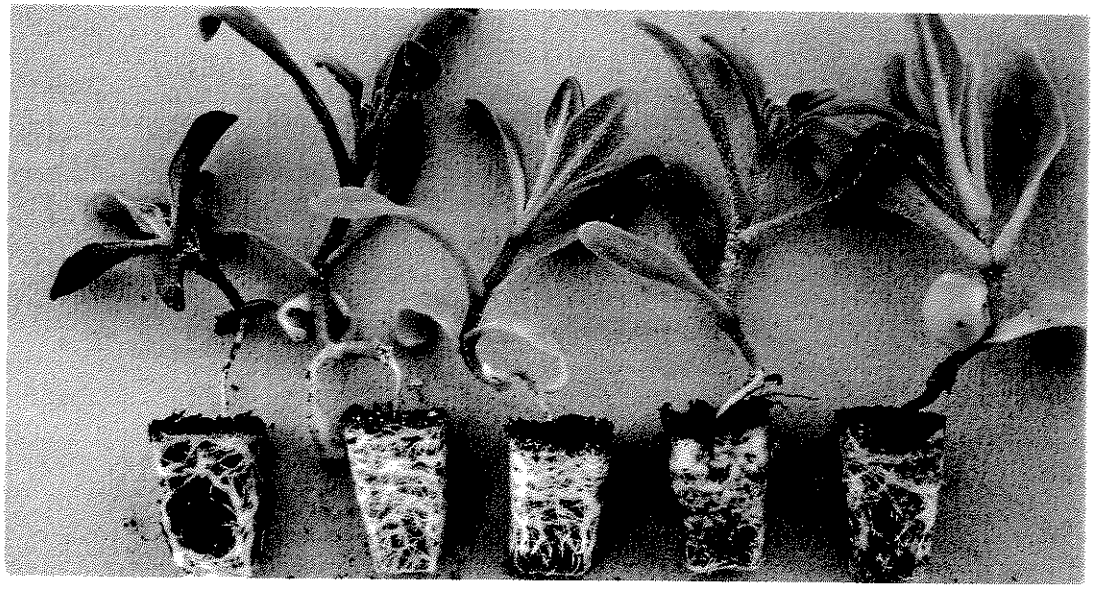
Treatment Level of Single Superphosphate (kg/m^3)

0 0.5 1.0 2.0 3.0

Pansy
'F1 Turbo Blue-White Bi-Colour'



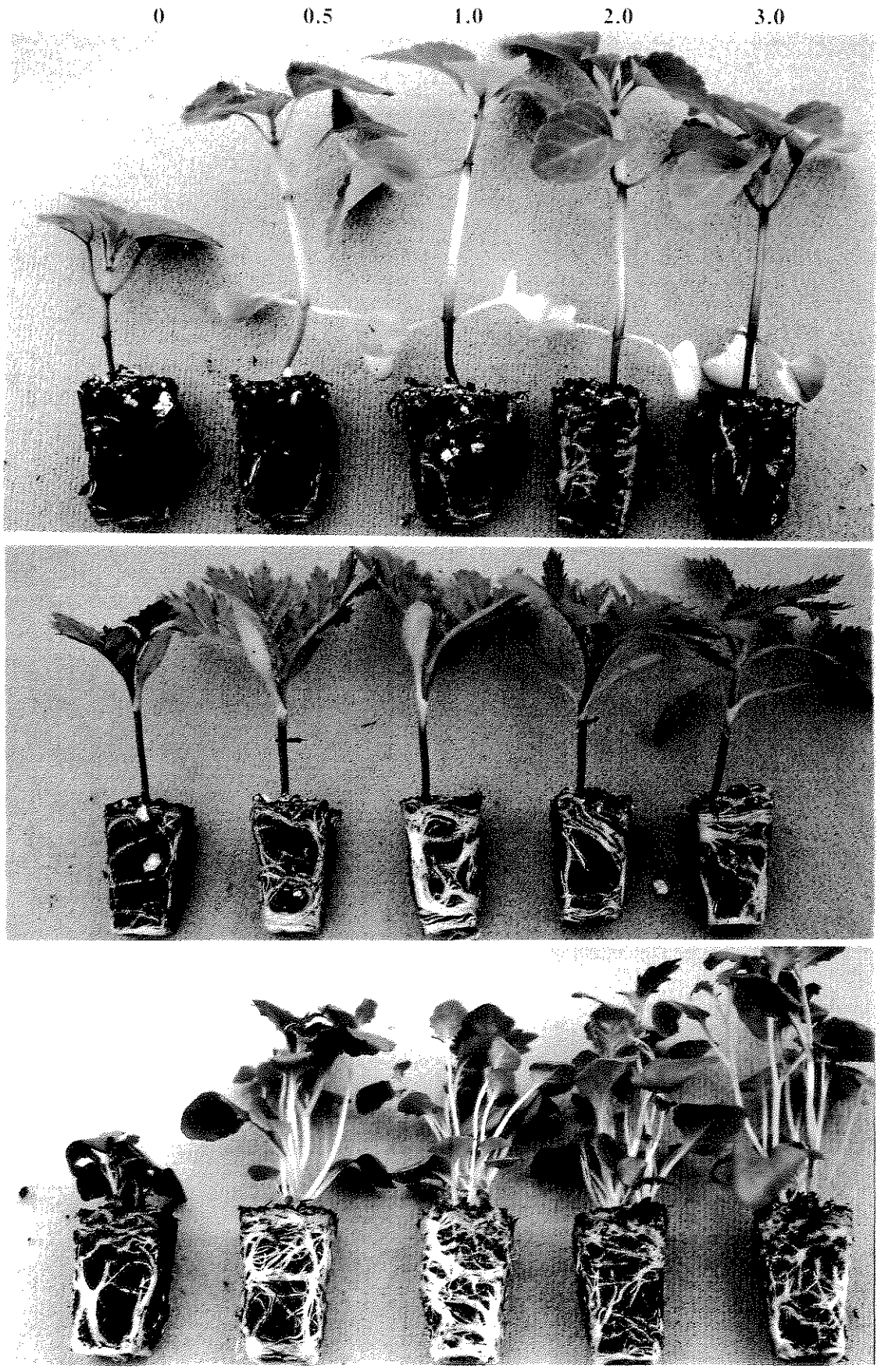
Mesembryanthemum
'Magic Carpet Mixed'



Alyssum
'Snowdrift'

APPENDIX IX

Plate 2: **Comparison of phosphate treatments at transplanting**



APPENDIX IX

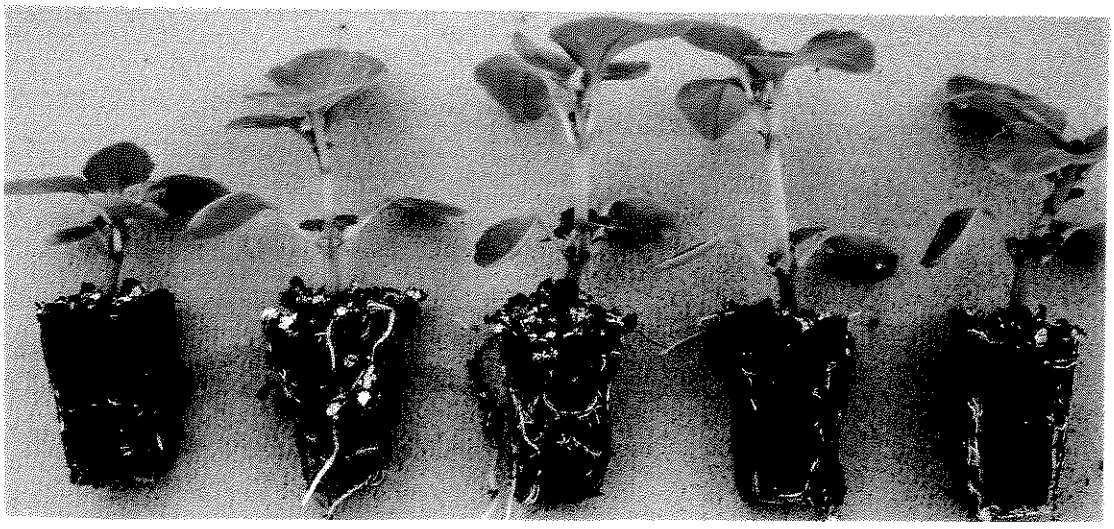
Plate 3: Comparison of phosphate treatments at transplanting

Treatment Level of Single Superphosphate (kg/m^3)

0 0.5 1.0 2.0 3.0

Petunia
'F1 Express
Blue Star'

Impatiens
'F1 Accent
Salmon'



APPENDIX IX

Plate 4: Comparison of watering regimes and phosphate treatments at maturity

Treatment Level of Single Superphosphate (kg/m³)

0 0.5 1.0 2.0 3.0

Watering Regime

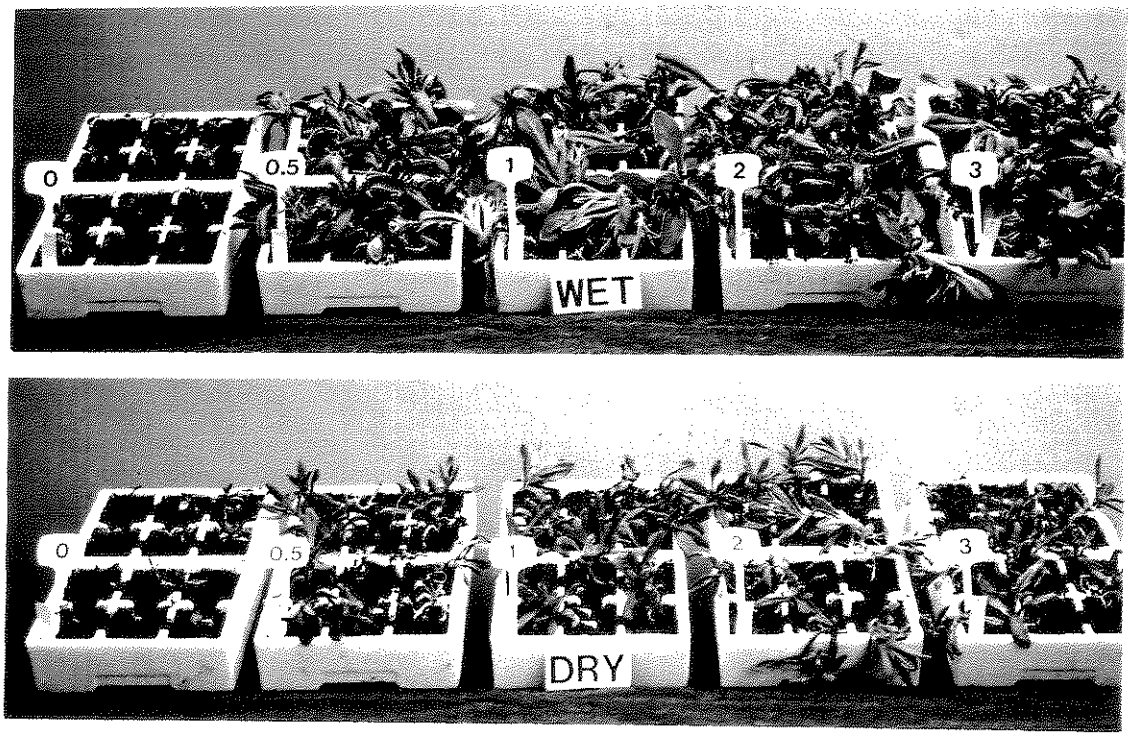
'Standard'

'Dry'

Pansy 'F1 Turbo Blue-White Bi-Colour'

'Standard'

'Dry'



Mesembryanthemum 'Magic Carpet Mixed'

APPENDIX IX

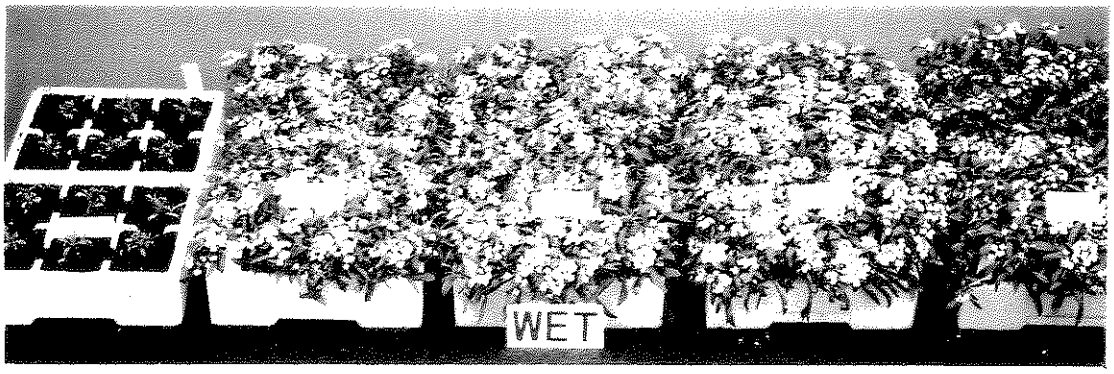
Plate 5: Comparison of watering regimes and phosphate treatments at maturity

Treatment Level of Single Superphosphate (kg/m^3)

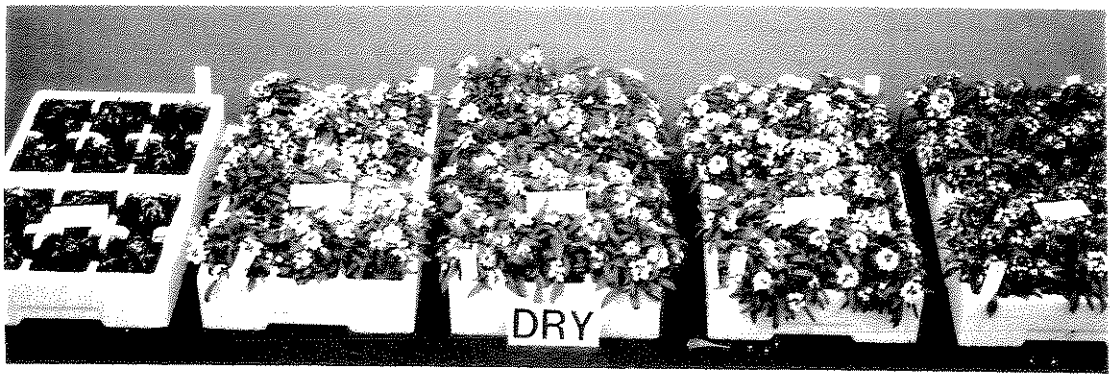
0 0.5 1.0 2.0 3.0

Watering Regime

'Standard'

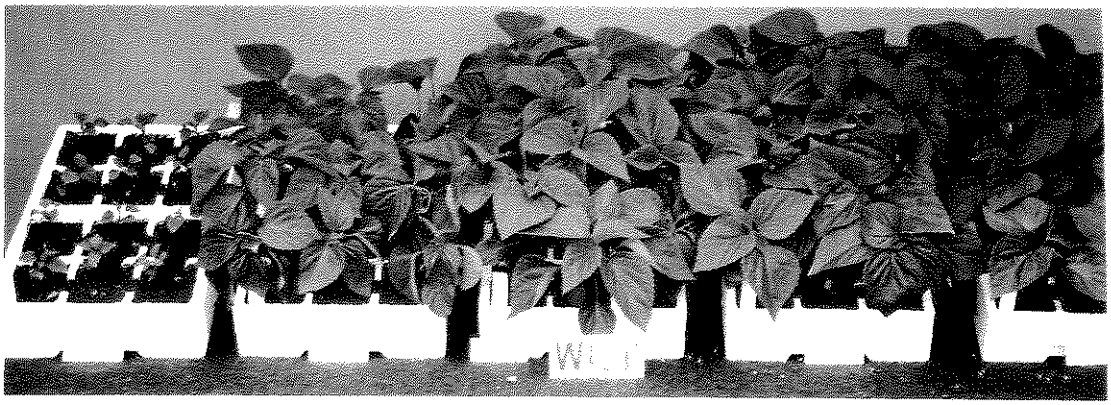


'Dry'



Alyssum 'Snowdrift'

'Standard'



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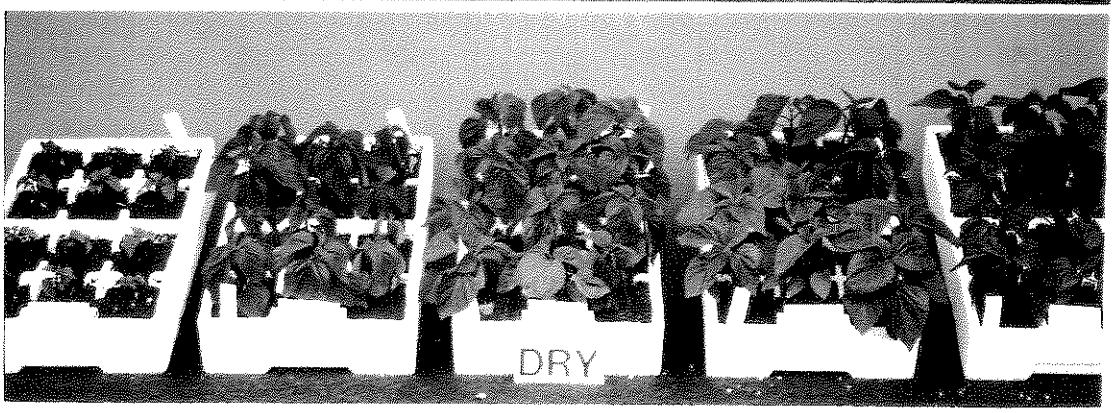


Salvia 'Vanguard'

APPENDIX IX

Plate 6: Comparison of watering regimes and phosphate treatments at maturity

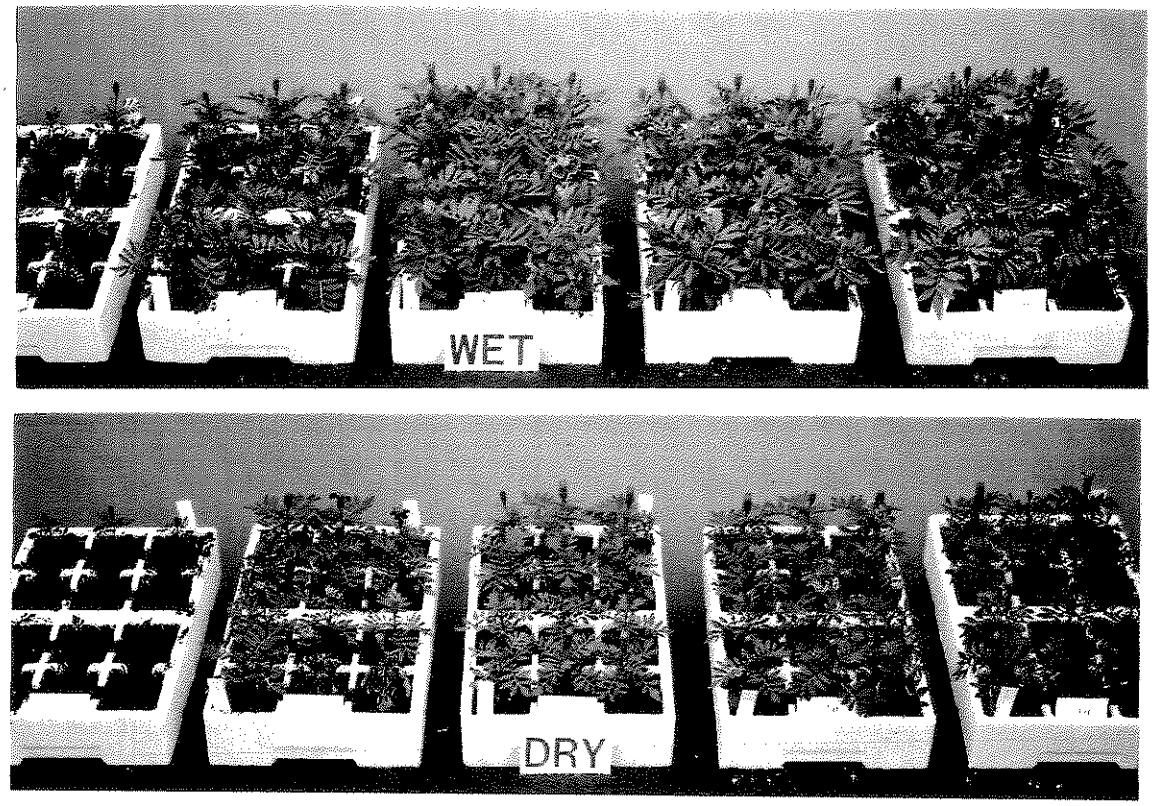
Treatment Level of Single Superphosphate (kg/m³)

0 0.5 1.0 2.0 3.0

Watering Regime

'Standard'

'Dry'



Marigold 'Aurora Fire'

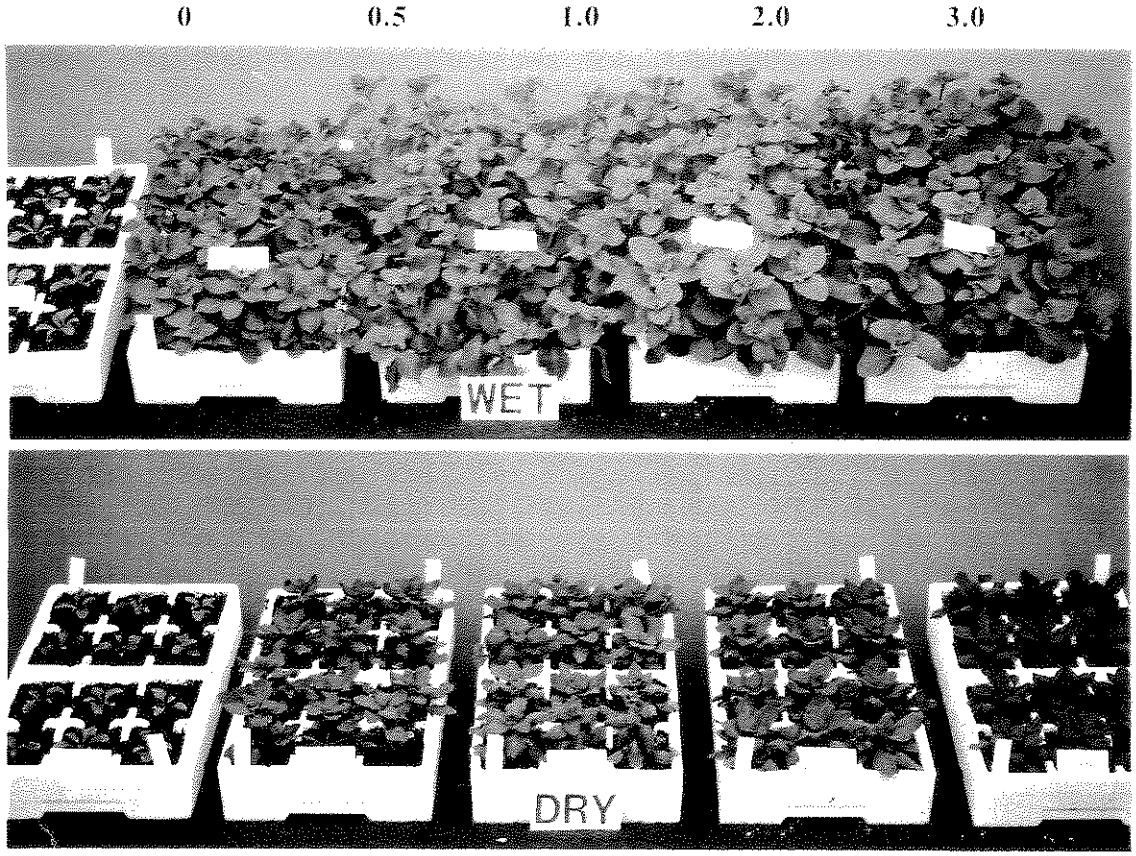
'Standard'

'Dry'

Lobelia 'Crystal Palace'

APPENDIX IX

Plate 7: Comparison of watering regimes and phosphate treatments at maturity



Petunia 'F1 Express Blue Star'

Impatiens 'F1 Accent Salmon'

APPENDIX X

References

Armitage, A.M. (1994) Ornamental Bedding Plants.
CAB International, Oxford, UK. p43-57

Dight, R.J.W. (1977) Nutritional Requirements for Bedding Plants.
Experimental Horticulture **29**, 63-71

Metcoff, L. (1992) Nutrition testing: a plant's four basic food groups.
Proceedings of the 1992 International Plug Conference, Orlando, Florida

APPENDIX XI

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

1. TITLE OF PROJECT

Contract No: PC86
Contract date: 20.12.93

BEDDING PLANTS: INVESTIGATION OF CULTURAL METHODS FOR CONTROLLING HEIGHT.

As for original contract.

Alternative methods for height control using the manipulation of nutrition (phosphate), plug size and the use of water stress on plants formed the basis of the 1993 trial at HRI Efford. The use of controlled phosphate deficiency as a means of height control, which had been used with success at Aalsmeer, proved less effective in this first trial, both during the plug and growing-on stage, and needs closer examination. However, marked height control was demonstrated using water stress during growing-on (particularly with Petunias) and needs further work to determine and measure the parameters required. Use of these techniques over a wider range of species than used in the first trial is required in order to produce schedules.

Garden performance is also important, especially in relation to speed of establishment and early performance of the 'restricted' plug compared to the more vigourous plants. Results of the 1993 trial in respect of shelf life have yet to be observed and may provide guidelines for future work.

3. POTENTIAL FINANCIAL BENEFIT TO THE INDUSTRY

As for original contract.

4. SCIENTIFIC/TECHNICAL TARGET OF THE WORK

As for original contract.

5. CLOSELY RELATED WORK - COMPLETED OR IN PROGRESS

As for original contract.

6. DESCRIPTION OF THE WORK IN YEAR 2

Level of phosphate:

i) 0 kg/m^3 (single superphosphate)
ii) 0.5 kg/m^3
iii) 1.0 kg/m^3
iv) 2.0 kg/m^3
v) 3.0 kg/m^3

Watering regime (during growing-on):

i. Standard
ii. Plants allowed to dry back until flaccid before watering.

Species:

Grown on at 12°C:	Alyssum
	Lobelia
	Mesembryanthemum
	Pansy
Grown on at 16°C:	Impatiens
	Marigold
	Petunia
	Salvia

All species to be sown into 286 plug trays in February except Marigold which will be sown in March. They will then be grown on in double six packs.

Design: Preliminary observation with limited replication.

5 phosphate levels
x
2 watering regimes during growing-on
x
2 replicates

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20 plots/species
x
8 species

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160 plots in total

Plot size: Plugs - central 20 plants recorded in each tray.

Growing-on - 12 plants recorded.

Garden performance: 6 plants of each plot to be planted out to evaluate effects on cultural treatments on 'shelf-life' and establishment.

Assessments:

a.	At plug stage:	Height of plants
		Quality score
		Vigour score
b.	At maturity:	Height score
		Double six pack weight

Quality score
Flowering score
Time to reach maturity

c. Garden performance: Size, vigour, quality and flowering scores to be taken on three occasions, June, July and August.

d. Photographs at all stages.

e. Frequency of watering when dry regime started.

7. **COMMENCEMENT DATE, DURATION AND REPORTING**

Start date 01.02.93; duration 2 years (10 months p.a.). A report for year 1 will be produced by 01.12.93 and the final report detailing the results from year 2 together with a summary of the results from year 1 will be produced by 01.12.94.

8. **STAFF RESPONSIBILITIES**

As for original contract.

9. **LOCATION**

As for original contract.