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CONTRACT REPORT

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# Bedding Plants:
# Effects of pH and phosphate on germination and emergence

for

Horticultural Development Council

PRINCIPAL WORKERS

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AUTHENTICATION

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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Summary

Peat based composts were prepared with a range of pH and phosphate levels and in various combinations. Seed of a range of bedding plant species (Impatiens, Marigold, Petunia, Primrose, Salvia and Verbena) were sown into trays of the experimental composts. Counts were made of seedling emergence.

pH levels below 4.0 greatly inhibited emergence of all species. Good germination was achieved at levels above 5.0.

Within the range tested, phosphate did not influence germination of any species.

## Introduction

Traditionally, bedding plant seed has been scatter sown into shallow boxes and pricked out into the final container 1 - 2 weeks later. Much of the seed used in the industry is expensive (up to 8p per seed in the case of Pelargonium zonale) and for this reason it has always been important to optimise the germination environment. Low germination percentages were acceptable, however, for low priced seed; the grower simply sows more thickly to compensate. Increasingly, seed is being direct sown into module trays or final containers. Under these circumstances where it is important that one plant develops at each station, high germination is essential.

This experiment is intended to examine two aspects of the chemistry of peat based composts on germination. It is intended that the outcome of the trial will be a recommendation for one compost type which will be suitable for a wide range of bedding plant species.

## Materials and Methods

### Treatments

1 Phosphate at 5 levels achieved by incorporating single superphosphate at (1) 2.0, (2) 1.0, (3) 0.5, (4) 0.25, (5) 0.12 kg/$m^3$ mixed compost (current ADAS recommendation is 0.75 kg/$m^3$)

2 pH at 9 levels achieved by incorporating ground limestone at (A) 0, (B) 1, (C) 2, (D) 3, (E) 4, (F) 5, (G) 6, (H) 7, & (I) 8 kg/$m^3$ mixed compost (current ADAS recommendation is 4.5 kg/$m^3$ for a 75% peat 25% sand compost

3 Species: selected by growers as presenting special difficulties in germination: Impatiens, Marigold, Petunia, Primrose, Salvia and Verbena

## Design

Each recorded plot consisted of 100 seeds in a standard half seed tray with three replicate plots in each run of the trial. The design was an incomplete factorial in which:

i) the effects of five levels of phosphate were tested at three levels of pH

ii) the effects of nine levels of pH were tested at one level of phosphate

Germination percentages were subject to angular transformation prior to analysis by regression. The effects of pH and phosphate were analysed separately in each case, the data being corrected for the effects of the second factor. Interpretation is further complicated by the unequal replication for different treatment combinations because of the nature of the incomplete factorial design. The tables of results accompanying statistical interpretation have been greatly simplified in the main body of the report with emphasis being placed on the practical rather than statistical significance.

## Cultural details

Medium Irish peat and sharp sand were mixed together in the ratio of 3:1 by volume. Potassium nitrate was added to this at the rate of 0.5 kg/$m^3$ of mixed compost (ADAS recommended rate).

This mix (termed red base) was used for all subsequent composts.

Three separate aliquots of red base were taken to which ground limestone was added at the following rates and mixed thoroughly:

| rate | name |
|---|---|
| 6 kg/$m^3$ | red G |
| 4 kg/$m^3$ | red E |
| 2 kg/$m^3$ | red C |

A portion of mix red G was taken and single superphosphate added at the rate of 2.0 kg/$m^3$. After mixing, half of this was set aside so as to become the compost containing 6 kg/$m^3$ of lime and the highest rate of phosphate. The remaining half was mixed with an equal quantity of red G so as to give a compost with the same lime rate but half of the phosphate. This was repeated three times more to give the range of five phosphate levels.

The same procedure was followed using the red E and red C bases.

A further quantity of red base was taken and single superphosphate incorporated at 1.0 kg/$m^3$. This mix was subdivided into six aliquots to which ground limestone was added at 0, 1, 3, 5, 7 and 8 kg/$m^3$. Samples of each compost were analysed using the peat method by ADAS Soil Science, Cambridge.

Sowing: seed was counted by hand and scatter sown onto the surface of half seed trays of the experimental composts (containing approximately 1.0 litre each). Where necessary, the seed was covered with the appropriate compost.

| Species | Covering |
|---|---|
| Impatiens | light |
| Marigold | complete |
| Petunia | nil |
| Primrose | nil |
| Salvia | light |
| Verbena | complete |

The trays were set out in a number of controlled temperature cabinets and rooms. A temperature of 20 - 22°C was used for germination of all but primroses which were germinated at 17 - 19°C. After setting out, the trays were covered with clear polythene film. Illumination was given 24 hours a day from fluorescent lamps to domestic levels of illuminance. The plastic film was removed once germination was under way.

The trial was conducted in 1987 and repeated in 1988.

Culture Diary

| Species | Variety | Seed house | Sown | Final |
|---|---|---|---|---|
| 1987 | | | | |
| Marigold | Naughty Marietta | Yates | 10 Sept | 18 Sept |
| Petunia | Galaxy | Yates | 22 Sept | 7 Oct |
| Salvia | Blaze of Fire | Browns | 10 Sept | 25 Sept |
| Verbena | Sparkle | Royal Sluis | 24 Sept | 29 Oct |
| 1988 | | | | |
| Impatiens | Dwarf Baby | Asmer | 11 Feb | 29 Feb |
| Petunia | Super Formula | Asmer | 11 Feb | 25 Feb |
| Primrose | Easter Bouquet | Asmer | 11 Feb | 3 March |
| Salvia | Blaze of Fire | Asmer | 11 Feb | 29 Feb |
| Verbena | Sparkle | Asmer | 11 Feb | 29 Feb |

Recording

Two counts were made of each species, the first when germination was underway and the second when germination appeared complete. On each occasion the total number of seeds germinated and the number of seedlings with healthy, expanded cotyledons was recorded.

Results

The method of analysis was complex and cannot readily be simplified.

Detailed results tables appear in Appendix I.

The tables below only cover aspects of the trial where statistically significant effects were observed.

Data have been transformed back into percentages although this should be regarded as an approximation only. It is not possible to detransform LSD's in this type of analysis. In the tables below it is most useful to look for trends in the data and to consider that only consistent effects are important.

Effects of pH level on the number of seedlings with expanded cotylendons at complete emergence (%), 1987 (See also Table 1, p 12)

Analysed

| pH | Marigold | Petunia | Salvia | Verbena | Mean |
|---|---|---|---|---|---|
| A 3.8 | 87 | 48 | 67 | 24 | 57 |
| B 4.6 | 89 | 62 | 81 | 35 | 67 |
| C 5.4 | 88 | 64 | 74 | 31 | 64 |
| D 6.1 | 92 | 64 | 84 | 25 | 66 |
| E 6.4 | 91 | 64 | 87 | 35 | 69 |
| F 6.7 | 91 | 67 | 85 | 45 | 72 |
| G 7.9 | 89 | 57 | 89 | 28 | 66 |
| H 6.9 | 88 | 57 | 91 | 41 | 69 |
| I 4.3 | 91 | 62 | 87 | 36 | 69 |
| | NS | * | * | NS | |

* Indicates effects significant at the 5% level

NS no significant effects

Effects of pH level on the number of seedlings with expanded cotyledons at complete emergence 1988 (%) (See also Table 2, p 13)

| | achieved pH | Impatiens | Petunia | Primrose | Salvia | Verbena | Mean |
|---|---|---|---|---|---|---|---|
| A | 3.6 | 60 | 18 | 1 | 38 | 1 | 27 |
| B | 4.2 | 77 | 35 | 11 | 60 | 0 | 41 |
| C | 5.1 | 82 | 38 | 12 | 77 | 6 | 46 |
| D | 5.7 | 78 | 36 | 12 | 78 | 4 | 45 |
| E | 6.4 | 85 | 41 | 14 | 79 | 9 | 49 |
| F | 6.3 | 82 | 40 | 11 | 78 | 7 | 47 |
| G | 6.6 | 81 | 35 | 14 | 79 | 11 | 47 |
| H | 6.7 | 74 | 40 | 12 | 78 | 6 | 45 |
| I | 6.7 | 86 | 43 | 5 | 65 | 8 | 44 |
| | | * | * | * | * | * | |

* Indicates effects significant at 5% level

Analysis -1987 results

Marigold

There was no significant evidence of either pH or phosphate level effects on germination

Petunia

a) There is some evidence at the 5% significance level that the lowest pH compost, A, gave lower germination rates

b) Phosphate effects. There is no evidence of significant phosphate level effects

Salvia

a) pH effects. There is very highly significant evidence of pH effects on germination rates with the low pH composts giving poorer rates of germination than the high pH composts

b) phosphate effects. There is some weak evidence at the 5% significance level of a phosphate level effect with the higher phosphate levels giving better germination rates than the lower phosphate levels

Verbena

There is no significant evidence of either pH level effects or phosphate level effects of germination rates

Analysis - 1988 results

Impatiens

a) pH effects. There is very highly significant evidence of pH effects with compost A, the low pH compost, giving relatively low germination rates.

b) Phosphate effects. There is some weak evidence of phosphate level effects on germination rates at the first count but there is no clear trend effect over the five phosphate levels and the analysis must be regarded with caution. There is no significant evidence of any phosphate level effects at the second count

Petunia

a) pH effects. There is very highly significant evidence of pH effects on germination rates with evidence that compost A, the lowest pH level, gave poor germination.

b) Phosphate effects. There is no significant evidence of phosphate level effects on germination rates

Primrose

a) pH effects. There is very highly significant evidence of pH level effects on germination rates but the effects are mainly due to the relatively low rates of germination with the low pH compost A

b) Phosphate effects. There is little significant evidence of phosphate level effects on germination rates except in the analysis of number of seedlings with expanded cotyledons at the second count which shows significant evidence at the 1% level. There is no evidence, however, of any consistent trend over the five levels, therefore this analysis must be treated with caution

Verbena

a) pH effects. There is very highly significant evidence of pH level effects on germination rates with good evidence that the germination rate increased with increasing pH level over the range of tested values

b) Phosphate effects. There is weak evidence at the 5% significance level of phosphate level effects on germination rates at the second count. The percentage of total seedlings visibly increased with increasing phosphate level at the second count but the percentage of expanded seedlings apparently shows an opposite trend with the percentage increasing as the phosphate level decreased.

## Discussion

There was no evidence of any effect of phosphate on germination over the range tested. No improvement in germination would be expected if phosphate levels in seed composts were reduced from the current ADAS recommendation of 0.75 $kg/m^3$. Similarly, no detriment to germination would be expected if levels were raised, eg to improve subsequent development and reduce the need to liquid feed phosphate.

The effects of pH were highly significant and consistent across the range of species. Only in the case of marigold was germination not impaired by pH levels below 4.0. Germination peaked in all species above pH 5.0. There was some evidence that higher pH values than 6.5 were detrimental in impatiens. The effect was small and would require further investigation.

## Conclusions

1 Within the range of 5.0 to 6.5 germination was not influenced by pH

2 Within the range tested, germination was not influenced by phosphate level

Appendix I - Tables of results

Each table shows the transformed germination for a range of pH or phosphate levels. Where significant difference exists at the p = 0.05 level or better, LSD's are given at the p = 0.05 level. As the level of replication varies between parts of the table, several LSD's are produced for each column. Use the LSD's marked ## for comparing two treatments both marked with a # // for comparing two treatments both marked with a hash, #/ comparing two treatments with different symbols.

Table 1: Effects of pH level on the number of seedlings with expanded cotyledons at complete emergence 1987

| | Marigold | | Petunia | | Salvia | | Verbena | |
|---|---|---|---|---|---|---|---|---|
| pH level | ang | % | ang | % | ang | % | ang | % |
| A # 3.8 | 69 | 87 | 44 | 48 | 55 | 67 | 29 | 24 |
| B # 4.6 | 71 | 89 | 52 | 62 | 64 | 81 | 36 | 35 |
| C / 5.4 | 70 | 88 | 53 | 64 | 59 | 74 | 34 | 31 |
| D # 6.1 | 74 | 92 | 53 | 64 | 66 | 84 | 30 | 25 |
| E / 6.4 | 72 | 91 | 53 | 64 | 69 | 87 | 36 | 35 |
| F # 6.7 | 72 | 91 | 55 | 67 | 67 | 85 | 42 | 45 |
| G / 7.9 | 71 | 89 | 49 | 57 | 71 | 89 | 32 | 28 |
| H # 6.9 | 70 | 88 | 59 | 57 | 72 | 91 | 40 | 41 |
| I # 4.3 | 72 | 91 | 52 | 62 | 69 | 87 | 37 | 36 |
| LSD between ## | ns | | 6.5 | | 4.3 | | ns | |
| // | | | 3.0 | | 2.8 | | ns | |
| #/ | | | 5.0 | | 4.6 | | | |

Table 2: Effects of pH level on the number of seedlings with expanded cotyledons at complete emergence 1988

| pH level | Impatiens ang | % | Petunia ang | % | Salvia ang | % | Primrose ang | % | Verbena ang | % |
|---|---|---|---|---|---|---|---|---|---|---|
| A # 3.6 | 51 | 60 | 25 | 18 | 33 | 38 | 5 | 1 | 5 | 1 |
| B # 4.2 | 61 | 77 | 36 | 35 | 51 | 60 | 19 | 11 | 3 | 0 |
| C / 5.1 | 65 | 82 | 38 | 38 | 61 | 77 | 20 | 12 | 14 | 6 |
| D / 5.7 | 62 | 78 | 37 | 36 | 62 | 78 | 20 | 12 | 12 | 4 |
| E / 6.4 | 67 | 85 | 41 | 41 | 63 | 79 | 22 | 14 | 17 | 9 |
| F # 6.3 | 65 | 88 | 39 | 40 | 62 | 78 | 19 | 11 | 15 | 7 |
| G / 6.6 | 64 | 81 | 36 | 35 | 63 | 79 | 22 | 14 | 19 | 11 |
| H # 6.7 | 59 | 74 | 39 | 40 | 62 | 78 | 20 | 12 | 14 | 6 |
| I # 6.7 | 68 | 86 | 39 | 43 | 54 | 65 | 13 | 5 | 16 | 8 |
| LSD between ## | 5.9 | | 6.1 | | 7.8 | | 6.0 | | 5.4 | |
| // | 2.7 | | 2.7 | | 3.5 | | 2.7 | | 2.4 | |
| #/ | 5.5 | | 5.6 | | 7.0 | | 5.5 | | 4.9 | |

Table 3: Effects of phosphate level on the number of seedlings with expanded cotyledons at complete emergence 1987

| Phosphate level | Marigold ang | % | Petunia ang | % | Salvia ang | % | Verbena ang | % |
|---|---|---|---|---|---|---|---|---|
| 1 # | 70 | 88 | 88 | 52 | 62 | 70 | 88 | 38 |
| 2 # | 69 | 69 | 87 | 50 | 59 | 69 | 87 | 31 |
| 3 / | 72 | 91 | 52 | 62 | 66 | 84 | 36 | 35 |
| 4 # | 70 | 88 | 50 | 59 | 62 | 78 | 31 | 27 |
| 5 # | 72 | 91 | 52 | 62 | 63 | 79 | 31 | 27 |
| LSD between / | ns | | ns | | 4.9 | | ns | |
| /# | ns | | ns | | 4.0 | | ns | |

Table 4: Effect of phosphate level on the number of seedlings with expanded cotyledons at complete emergence 1988

| | Impatiens | | Petunia | | Salvia | | Petunia | | Verbena | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ang | % | ang | % | ang | % | ang | % | ang | % |
| 1 # | 65 | 82 | 39 | 40 | 60 | 75 | 20 | 12 | 14 | 6 |
| 2 # | 64 | 81 | 38 | 38 | 60 | 75 | 33 | 14 | 15 | 7 |
| 3 / | 63 | 79 | 36 | 35 | 59 | 74 | 18 | 10 | 13 | 5 |
| 4 # | 67 | 85 | 38 | 38 | 63 | 79 | 22 | 14 | 18 | 10 |
| 5 # | 65 | 82 | 39 | 40 | 63 | 79 | 23 | 15 | 17 | 9 |
| LSD ## | ns | | ns | | ns | | 4.28 | | 3.71 | |
| /# | | | | | | | 3.49 | | 3.03 | |

Appendix II - results of compost analysis

| | | 1987 | | 1988 | |
|---|---|---|---|---|---|
| limestone kg/m$^3$ | single super-phosphate kg/m3 | pH | phosphorus mg/litre | pH | phosphorus mg/litre |
| C1 2.0 | 2.00 | 5.1 | 109 | 4.9 | 82 |
| C2 2.0 | 1.00 | 5.2 | 48 | 5.0 | 46 |
| C3 2.0 | 0.50 | 5.4 | 24 | 5.1 | 24 |
| C4 2.0 | 0.25 | 5.3 | 15 | 5.1 | 12 |
| C5 2.0 | 0.12 | 5.4 | 10 | 5.2 | 6 |
| E1 4.0 | 2.00 | 6.3 | 97 | 5.9 | 67 |
| E2 4.0 | 1.00 | 6.4 | 47 | 6.1 | 36 |
| E3 4.0 | 0.50 | 6.4 | 32 | 6.4 | 30 |
| E4 4.0 | 0.25 | 6.5 | 18 | 6.4 | 21 |
| E5 4.0 | 0.12 | 6.4 | 21 | 6.4 | 5 |
| G1 6.0 | 2.00 | 6.7 | 42 | 6.3 | 48 |
| G2 6.0 | 1.00 | 4.6 | 12 | 6.5 | 26 |
| G3 6.0 | 0.50 | 7.9 | 7 | 6.6 | 15 |
| G4 6.0 | 0.25 | 7.2 | 3 | 6.7 | 7 |
| G5 6.0 | 0.12 | 7.1 | 6 | 6.8 | 28 |
| H3 7.0 | 0.50 | 6.9 | 19 | 6.7 | 31 |
| D3 3.0 | 0.50 | 6.1 | 31 | 5.7 | 35 |
| I3 8.0 | 0.50 | 4.3 | 22 | 6.7 | 25 |
| F3 5.0 | 0.50 | 6.7 | 49 | 6.3 | 39 |
| B3 1.0 | 0.50 | 4.6 | 41 | 4.2 | 86 |
| A3 0.0 | 0.50 | 3.8 | 48 | 3.6 | 51 |