Agricultural Development and Advisory Service

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CONTRACT REPORT

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Bedding Plants: Effects of pH, phosphate and nitrate on germination

Undertaken for Horticultural Development Council

PRINCIPAL WORKER

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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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EFFECTS OF NITRATE AND PHOSPHATE ON GERMINATION

Summary

A compost was made from 3 parts medium grade Irish peat (pH 4.1) plus 1 part grit. This was tested with and without the addition of lime, phosphate and nitrogen (either as ammonium nitrate or as urea) at various levels and combinations.

The addition of lime to raise the pH of raw peat was shown to be essential for optimum germination. The addition of phosphate or nitrogen or both tended to reduce germination broadly in line with their effects on compost conductivity, nitrogen having the stronger effect of the two nutrients with little difference between the two nitrogen sources.

It was concluded that the best peat compost for seed germination is one in which the pH has been raised by lime but the conductivity has not been increased by the addition of nutrients.

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 for low priced seed, the grower simply sowing more thickly to compensate. Increasingly, seed is being sown direct into module trays or final containers. Under these circumstances where it is important that one plant develops at each station, high germination is essential.

Nitrates and conductivity: In previous trials seedling emergence was inhibited in direct proportion to increased conductivities resulting mainly from the use of nitrate fertilisers. As urea raises the conductivity less than ammonium nitrate for the same amount of nitrate available, the two sources of nitrogen were used again at standard rate (100 mg/litre N) and a high rate (400 mg/litre N).

Phosphates: In previous trials phosphate had not influenced germination of any species in the range of levels tested. To confirm this, one phosphate source was used at standard rate (60 - 68 mg/litre P) and a high rate (160 - 180 mg/litre P).

pH: Levels below pH 4.0 impair germination. In this trial the aim was to raise the pH of compost to 5.5 to 5.8 using ground limestone prior to the addition of other fertilisers.

This trial was intended to further examine the effects of varying levels of nitrate, phosphate, pH and conductivity on the germination of bedding plant seeds. The objective was to make a recommendation for one compost which is suitable for a wide range of bedding plant species.

Materials and Method

Treatments

Ten treatments were used as follows:

All 10 were based on a mixture of 3 parts medium grade Irish peat + 1 part grit

A) Straight compost - no additions - pH 4.1

B) Compost + lime - to pH 5.5 - 5.8 (ground limestone 4.22 kg/m^3)

C) Compost + lime + superphosphate at standard ADAS rate (0.75 kg/m^3)

D) Compost + lime + superphosphate + ammonium nitrate at standard ADAS rate (0.29 kg/m^3)

E) Compost + lime + superphosphate + urea at standard ADAS rate (0.22 kg/m^3)

F) Compost + lime + superphosphate at high rate (2 kg/m^3)

G) Compost + lime + superphosphate at standard ADAS rate + ammonium nitrate at high rate (1.16 kg/m^3)

H) Compost + lime + superphosphate at standard ADAS rate + urea at high rate (0.87 kg/m^3)

I) " " " + ammonium nitrate at standard ADAS rate

J) " " " + urea at standard ADAS rate

Species: Petunia, Primrose, Salvia and Verbena. These were the same as had been used in previous trials and they were chosen to represent commonly grown species which can be difficult to germinate. Impatiens was included but, owing to a problem with the seed, the results with this species were unreliable and it has been excluded from the report.

Design

Each recorded plot consisted of 100 seeds in a standard half seed tray with five replicate plots arranged in randomised blocks. The design was partly factorial and has been divided for analysis as follows:

1. A set of four unstructured treatments consisting of treatments A, F, G and H.

2. A set of six structured treatments comprising treatments B, C, D, E, I and J as a 3 x 2 factorial experiment with two phosphate levels (none and standard) and three nitrate levels (none and ammonium nitrate or urea at standard rates)

Cultural details

Medium Irish peat and 3 mm non-calcareous grit were mixed together in the ratio of 3:1 by volume. Sufficient was removed for compost A and the remainder was neutralised with ground limestone at the rate of 4.22 kg/m^3 to raise the pH to 5.5 - 5.8.

Each treatment was then made up by incorporating fertilisers thoroughly as follows:

Nutrient target levels and fertiliser rates

	target Mg/litre	Fertiliser	rate kg/m^3
Standard ADAS rate of P	60- 68	Single superphosphate	0.75
High rate of P	160-180	" "	2.00
Standard ADAS rate of N	100	Ammonium nitrate (34.5% N)	0.29
	100	Urea (46% N)	0.22
High rate of N	400	Ammonium nitrate	1.16
	400	Urea	0.87

Samples of each compost were analysed by ADAS Soil Science, Cambridge (see appendix).

Sowing: Half seed trays were almost completely filled with approximately one litre of the experimental compost

Seed was counted by hand and on 19 October was scatter sown onto the surface of the composts. Where necessary, seed was covered with the appropriate compost.

Species	Covering
Petunia	nil
Primrose	nil
Salvia	light
Verbena	complete

The trays were set on a low raised bench in an insulated germination room. A temperature of 20 - 22°C was used for germination for all but Primroses which were germinated at 17 - 19°C by placing trays directly on the floor towards the cooler sides of the room. After setting out in randomised blocks the trays were covered with clear polythene film. Illumination was given 24 hours a day from fluorescent and tungsten lamps commencing at 100 lux and increasing to 1000 lux upon germination when the polythene film was removed.

Culture Diary

Seed sown on 19 October

Species	Variety	Seed House	Recording date
Petunia	Formula mixed	Asmer	2 Nov
Primrose	Budermier Yellow	"	9 Nov
Salvia	Blaze of Fire	"	3 Nov
Verbena	Sparkle Mixed	"	4 Nov

Recording

A count was made, when germination appeared to be complete, of the number of seedlings with healthy, expanded cotyledons

Results

Table 1: Petunia - percentage seedlings with healthy expanded cotyledons on 2 November (14 days after sowing)

Nitrogen		Rate of application			
		Phosphate			
		Nil	Standard	Nil + Standard mean	High
		No lime or nutrients = 23.6 A			
Nil		42.2 B	45.6 C	43.9 $\frac{B+C}{2}$	41.6 F
Am. nitrate	standard	33.8 I	43.8 D	38.8 $\frac{I+D}{2}$	
	high		15.4 G		
Urea	standard	50.6 J	32.2 E	41.4 $\frac{J+E}{2}$	
	high		14.4H		
Mean		42.2 $\frac{(B+I+J)}{3}$	40.5 $\frac{(C+D+E)}{3}$		

SED's between $\frac{B+I+J}{3}$ and $\frac{C+D+E}{3}$ = 4.39 (36 df)

" $\frac{B+C}{2}$, $\frac{I+D}{2}$ and $\frac{J+E}{2}$ = 5.38 (36 df)

" individual figures = 7.60 (36 df)

Letters after figures in the Tables identify treatments

Petunia

1 The addition of lime (B) to raw peat (A) was essential to improve germination

2 The addition of superphosphate at either the standard rate (C) or the high rate (F) did not have a significant effect ($P > 0.05$)

3 The addition of nitrogen at the standard rate (means of I + D or J + E) did not have a significant effect but the high rates (G) and (H) significantly depressed germination. There was no significant difference between the effects of ammonium nitrate and urea

4 There was a significant interaction between the standard rate of urea and phosphate: the combination of urea and phosphate (E) depressed germination compared with urea alone (J) or phosphate alone (C)

Table 2: Primrose - percentage seedlings with healthy expanded cotyledons on 9 November (21 days after sowing)

Nitrogen		Rate of application: Phosphate Nil	Standard	Nil + Standard mean	High
		No lime or nutrients = 0.8 A			
Nil		13.0 B	14.8 C	13.9 $\frac{B+C}{2}$	11.4 F
Am. nitrate	standard	13.2 I	14.6 D	13.9 $\frac{I+D}{2}$	
	high		4.2 G		
Urea	standard	10.8 J	10.4 E	10.6 $\frac{J+E}{2}$	
	high		0.2 H		
Mean		12.3 $\frac{B+I+J}{3}$	13.3 $\frac{C+D+E}{3}$		

SED's between $\frac{B+I+J}{3}$ and $\frac{C+D+E}{3}$ = 1.035 (36 df)

" $\frac{B+C}{2}$, $\frac{I+D}{2}$ and $\frac{J+E}{2}$ = 1.267 (36 df)

" individual figures = 1.792 (36 df)

Primrose

1 The addition of lime (B) to raw peat (A) was essential to improve germination

2 The addition of superphosphate at the standard rate (mean of C, D and E) did not have a significant effect on germination when compared with no phosphate (mean of B, I and J). Similarly, the difference between the high rate of phosphate (F) and the nil rate (B) or low rate (C) was insignificant ($P > 0.05$)

3 The standard rate of ammonium nitrate (mean of I and D) had no effect compared with the mean of (B) and (C). However, the standard rate of urea (mean of J and E) depressed germination to an extent which was just significant ($P < 0.05$). The high rates of both sources of nitrogen depressed germination very significantly, urea (H) being significantly more damaging than ammonium nitrate (G)

4 The analysis showed no evidence of phosphate by nitrogen interactions

Table 3: Salvia - percentage seedlings with healthy expanded cotyledons on 3 November (15 days after sowing)

Nitrogen		Rate of application – Phosphate: Nil	Standard	Nil + Standard mean	High
		No lime or nutrients = 63.6 A			
Nil		83.6 B	80.2 C	81.9 $\frac{B+C}{2}$	79.6 F
Am. nitrate	standard	81.8 I	74.8 D	78.3 $\frac{I+D}{2}$	
	high		70.8 G		
Urea	standard	84.4 J	73.2 E	78.8 $\frac{J+E}{2}$	
	high		65.2 H		
Mean		83.3 $\frac{B+I+J}{3}$	76.1 $\frac{C+D+E}{3}$		

SED's between $\frac{B+I+J}{3}$ and $\frac{C+D+E}{3}$ = 2.74 (36 df)

" $\frac{B+C}{2}$, $\frac{I+D}{2}$ and $\frac{J+E}{2}$ = 3.35 (36 df)

" individual figures = 4.74 (36 df)

Salvia

1 The addition of lime (B) to raw peat (A) was essential to improve germination

2 The addition of superphosphate at the standard rate (mean of C, D and E) depressed germination to an extent which was just significant ($P < 0.05$) compared with the mean of treatments (B), (I) and (J). The effect of superphosphate at the high rate was not significantly more severe than that of the standard rate

3 The addition of nitrogen at the standard rate (means of I + D or J + E) did not have a significant effect but the high rates (G) and (H) significantly depressed germination. There was no significant difference between the effects of ammonium nitrate and urea

4 The analysis showed no evidence of phosphate by nitrogen interactions

Table 4: Verbena - percentage of seedlings with healthy expanded cotyledons on 4 November (16 days after sowing)

Nitrogen		Rate of application: Phosphate Nil	Standard	Nil + Standard mean	High
		No lime or nutrients = 9.4 A			
Nil		29.0 B	28.2C	28.6 $\frac{B+C}{2}$	22.4 F
Am. nitrate	standard	21.6 I	17.8 D	19.7 $\frac{I+D}{2}$	
	high		3.2 G		
Urea	standard	22.0 J	17.4 E	19.7 $\frac{J+E}{2}$	
	high		4.6 H		
Mean		24.2 $\frac{(B+I+J)}{3}$	21.1 $\frac{(C+D+E)}{3}$		

SED's between $\frac{B+I+J}{3}$ and $\frac{C+D+E}{3}$ = 1.453 (36 df)

" $\frac{B+C}{2}$, $\frac{I+D}{2}$ and $\frac{J+E}{2}$ = 1.78 (36 df)

" individual figures = 2.517 (36 df)

Verbena

1 The addition of lime (B) to raw peat (A) was essential to improve germination. None of the other treatments produced significantly better germination than (B)

2 The standard rate of phosphate (mean of C, D and E) depressed germination to an extent which was just significant ($P < 0.05$) when compared with no phosphate (mean of B, I and J). The high addition of phosphate (F) further depressed germination compared with standard phosphate (C)

3 The standard rate of nitrogen (means of I + D or J + E) depressed germination to a highly significant extent ($P < 0.01$) The high rates of nitrogen (G) and (H) were even more damaging. There was no significant difference between the effects of ammonium nitrate and urea, both sources of nitrogen being equally damaging

4 The analysis showed no evidence of phosphate by nitrogen interactions

Discussion

The importance of adding lime to raise the pH of the compost was demonstrated by all four species.

Adding phosphate or nitrogen tended to be detrimental to germination. This is thought to result from the increase in conductivity which occurs when these materials are included in the compost (see Appendix). The high rate of nitrogen was particularly damaging on all species and there was little to choose between ammonium nitrate and urea even though the latter had a smaller effect on conductivity. Primrose appeared to be particularly sensitive to urea at both rates. Only Verbena was sensitive to both sources of nitrogen at the low rate.

The addition of phosphate at either standard or high rates did not have a significant effect on germination of Petunia or Primrose. However, at the standard rate it depressed germination of Salvia and Verbena. Salvia was not further depressed by the high rate of phosphate but Verbena was.

The combinations of nitrogen plus phosphate, which resulted in higher conductivities, tended to have more severe effects on germination than when either material was used alone.

Conclusions

1 The addition of lime to raise the pH of raw peat (to approximately 5.6) is essential for optimum germination

2 The addition of phosphate or nitrogen will not improve germination. The addition of these materials is much more likely to reduce germination, the degree of this effect being in line with their effect on compost conductivity

3 The best peat compost for seed germination is one in which the pH has been raised to approximately 5.6 but the conductivity has not been increased by the addition of nutrients. (Liquid feeding was not included in these experiments but it is reasonable to suppose that, if a peat compost with no added nutrients was used for germination, a liquid feed containing N, P and K would be needed very soon after emergence).

4 These conclusions are consistent with those obtained from previous trials done for the HDC

APPENDIX

Results of Compost Analysis

	Start				Finish			
Treat-ment	pH	cf uS	Phos. mgl/	NO_3+ NH_4 mg/l	pH	cf uS	Phos. mg/l	NO_3+ NH_4 mg/l
A	4.2	60	1	22	4.3	80	8	15
B	4.3	160	3	32	6.8	185	4	17
C	6.2	220	30	32	6.1	185	14	17
D	6.0	275	31	159	6.0	200	14	48
E	6.5	260	31	81	6.2	190	21	65
F	6.3	360	89	51	5.8	275	32	18
G	6.3	465	28	402	6.9	505	11	326
H	6.5	300	29	137	7.4	315	10	159
I	6.6	240	3	130	6.9	195	3	114
J	6.6	200	1	84	6.7	160	5	74