

eas of rich wilderness. In addition to the plants any travelling experience rewards with experience of a rich variety of culture and the interaction with Chilean people, which gave me greater understanding of political, cultural, and economic issues.

I have already been able to put into practice at Inverewe some new propagating ideas developed from observations made in natural habitats in Chile, for example using smoke and heat treatments to stimulate germination of seed of some *Nothofagus* species. Any horticulturist should be encouraged to go and observe plants in their natural habitat for themselves, as it certainly alters one's outlook on plant husbandry back home.

Acknowledgements. I would like to say thank you to all the sponsors of the Mary Helliard Travel Scholarship who helped to make this expedition possible. I would also like to thank all the people that I met along the way for being wonderfully kind and friendly and for enhancing my time in Chile, and Martin Gardens of RGB Edinburgh for his help.

My full report "A Plant Exploring Trip to Chile" is available on loan from the I.P.P.S. Region of Great Britain and Ireland Region Office.

New Fertilisers for Herbaceous and Bedding Propagation®

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STIMUL-8¹ and PROPAG-8² are novel patent-pending fertilisers with biostimulant benefits and are in commercial use on a range of horticultural crops, including strawberries and chrysanthemums. In trials conducted over a 2-year period in crops of strawberry (*Fragaria ×ananassa*, botanically a herbaceous perennial) the fertilisers resulted in large and statistically significant ($p < 0.05$) increases in the amount of rooting, plant biomass, and number of crowns by the end of the propagation phase compared with the control treatments using standard proprietary fertilisers. Trials were also conducted on a selection of ornamental herbaceous and bedding species during propagation, and these showed that across the seven species investigated, repeat applications of STIMUL-8 (both at 7-day and 10- to 14-day intervals) resulted in the following mean benefits over the equivalent N : P : K : S fertiliser control treatment: rooting: +13.7% (7-day); +11.9% (10-14 day); vigour: +6.7%; +7.1%; plant biomass: +7.0%; +7.9%; number of crowns or apical meristems: +18.0%; +23.6%; number of flower stems: +16.0%; +26.1%. Many of these results were statistically significant ($p < 0.05$) for each attribute within each species.

Species investigated: *Viola* (pansy), *Helichrysum petiolare*, *Begonia* F1 Hybrid 'Nonstop Rose Petticoat', *Sedum spectabile*, *Geranium ×cantabrigiense* 'Cambridge', *Pelargonium* 'Red Mini Cascade' and *Plectranthus variegatus*.

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INTRODUCTION

STIMUL-8® and PROPAG-8® are two novel patent-pending fertilisers with biostimulant benefits (Mandops (UK) Ltd; IPPN WO 00/46169, 2000) which contain phosphorus in the form of phosphonate (= phosphite, salts of phosphorous acid), in mixture with a thiosulphate. Phosphonate and thiosulphate mixtures result in synergistic biostimulant benefits to rooting, vigour, and above-ground biomass across a wide range of species. In trials conducted over a 2-year period in crops of strawberry (*Fragaria xananassa*, botanically a herbaceous perennial, Hancock, 1999) in 2000 and 2001 these fertilisers showed large and significant increases in rooting, biomass, and number of crowns by the end of transplant (see Tables 1 and 2) compared to standard proprietary fertilisers. Trials were subsequently undertaken on a selection of herbaceous perennial and bedding species to further investigate the effects of STIMUL-8 and PROPAG-8 on rooting and above-ground growth. This paper presents the results of this work.

MATERIALS AND METHODS

Crop Production. Trials were conducted on seedlings grown at White Moss Garden Centre, Widnes, Cheshire, under glasshouse conditions, between late April and early July 2002. The trials were under normal ambient glasshouse conditions, with anti-frost protection of a minimum temperature of 4°C, and with automatic ventilation at 16°C. Watering was carried out on a regular basis. The seed compost was peat based, containing 1.5 kg·m⁻³ of Kemira NPK fertiliser (13-15-17) containing magnesium and sulphur (1.0% MgO + 10% SO₃) with trace elements. The rooted plants were later transplanted into potting compost containing 4.0 kg·m⁻³ of the same fertiliser. The pH of both compost mixtures was 6.5, with a cf of 1250 min, and an AFP of 12.

The following species were bought in as plugs (2 cm), and subsequently potted on into 9-cm pots on 20 May 2002: *Helichrysum petiolare*, *Pelargonium* 'Red Mini Cascade', and *Begonia* F1 hybrid 'Nonstop Rose Petticoat'. *Viola* (pansy) was grown from seed on 12 April 2002, and pricked out into six pack trays on 28 May 2002. *Geranium xcantabrigiense* 'Cambridge' was grown in 9-cm square pots and potted on into 1-litre pots on 13 May 2002.

Treatments. The following treatments were applied:

- 1) Untreated: water only; no standard fungicide or fertiliser regime besides base fertiliser.
- 2) Standard fungicide regime, but no added fertiliser.
- 3) STIMUL-8 applied at 1.5 litres ha⁻¹ in 200 litres water at one-true-leaf stage, this dose being repeated every 7 days until crowns or apical meristems had formed. After these applications, PROPAG-8 was applied at 2.0 litres ha⁻¹ in 200 litres water every 10 to 14 days. Standard fungicide regime as in (Treatment 2) above was adopted. Six applications of STIMUL-8 were made (applied 29 April, 6 May, 13 May, 20 May, 27 May and 3 June), plus two of PROPAG-8 (applied 19 June and 3 July).
- 4) STIMUL-8 applied at 2.0 litres ha⁻¹ in 200 litres water at one true leaf, and this dose repeated every 14 days until crowns or apical meristems had formed, followed by PROPAG-8 at the same

Table 1. Effect of STIMUL-8 application on growth attributes of *Fragaria xananassa* during propagation Year 2000 Trial.

Treatment	'Elsanta'		'Symphony'	
	Rooting (0-9)	Biomass (0-9)	Rooting (0-9)	Biomass (0-9)
Control (fungicides only)	3.3a*	3.5a	3.3a	4.3a
STIMUL-8 every 7 days (seven applications) 1.5 litres ha ⁻¹	4.5b	7.3b	5.7c	7.6b
STIMUL-8 applied every 14 days (four applications) 2 litres ha ⁻¹	3.3a	5.8b	4.2b	6.4b
LSD (P = 0.05)	0.93	1.68	0.85	1.56
LSD (P = 0.01)	1.26	2.27	1.15	2.11

*Duncan's multiple range test: mean values with the same letter within a measurement are not significantly different at the 5% (p<0.05) probability level. The same applies to the other Tables (Tables 2 to 10).

Table 2. Effect of STIMUL-8 application on growth attributes of *Fragaria xananassa* during propagation Year 2001 Trial.

Treatment	'Elsanta'			'Symphony'		
	Rooting (0-9)	Biomass (0-9)	Crown (no.)	Rooting (0-9)	Biomass (0-9)	Crown (no.)
Control (fungicides only)	5.0a	5.0a	1.5a	5.4a	4.8a	2.1a
STIMUL-8 every 7 days (seven applications)						
1.5 litres·ha ⁻¹	5.7c	5.3b	1.8b	6.0b	4.9a	2.4a
STIMUL-8 applied every 14 days (four applications)						
2 litres·ha ⁻¹	5.4b	4.9a	1.4a	5.5a	4.9a	2.1a
LSD (P = 0.05)	0.22	0.22	0.28	0.27	0.22	0.32
LSD (P = 0.01)	0.31	0.31	0.39	0.38	0.31	0.45

- rate and timing as in (Treatment 3) above. Standard fungicide regime as in (Treatment 2) above was adopted. Four applications of STIMUL-8 were made (applied 29 April, 13 May, 27 May and 10 June), plus two of PROPAG-8 (applied 19 June and 3 July).
- 5) NPKS fertiliser mixture, comprising very similar foliar nutrition to STIMUL-8 in (Treatment 3) above (i.e., 2.6% w/w N, 7.4% w/w P as P₂O₅, 5.4% K as K₂O, and 15.2% w/w S as SO₃). This was applied at 1.5 litres ha⁻¹ in 200 litres water at one-true-leaf stage, with the dose repeated at rates, timings, and dates as in (Treatment 3) above. This was followed by two applications of PROPAG-8 at rates, timings, and dates of (Treatment 3) above. Standard fungicide regime as in (Treatment 2) above was adopted. Standard fungicides were applied at their recommended rates and water volumes as follows: Bedding: 75% oxycarboxin (Plantvax 75; Fargro) on 29 April and 24 May; Herbaceous: 6% myclobutanil (Systhane 6 W; Dow) on 3 May and 19 May; prochloraz (Scotts Octave; Scotts) on 6 June.

Trial Design, Measurements, and Statistical Analysis. All trials were randomised block designs with five replicates per treatment. Plot size was a single plant per pot. Measurements were taken as follows: plant vigour assessments (0 to 9 score) on 10 June; number of flower stems and number of apical meristems or crowns on 25 June, and above-ground biomass and rooting (0 to 9 score) on 10 July. An analysis of variance (ANOVA) was performed on the data. Individual treatment means were compared with the least significant difference (LSD) at probabilities of 5% ($P = 0.05$) and 1% ($P = 0.01$). Duncan's multiple range test was then performed, in order to make all possible comparisons between means. Individual means with the same letter were not significantly different at the 5% probability level ($P < 0.05$).

RESULTS

The results presented in Tables 4 to 10 showed that each of the two foliar-applied STIMUL-8 treatments (Treatments 3 and 4; applied every 7 days and every 10 to 14 days from the one-leaf stage) resulted in statistically significant (at $P < 0.05$ and often at $P < 0.01$) benefits over the NPKS fertilizer control treatment in rooting, vigour, biomass, number of crowns, or apical meristems, and number of flower stems, in each of the seven species investigated. These results were similar to the earlier work on strawberry (Tables 1 and 2).

DISCUSSION

The trials results demonstrate improved plant growth using STIMUL-8 either applied every 7 days from the one-leaf stage during propagation (treatment 3, six applications in total), or applied every 10 to 14 days (Treatment 4, four applications in total). The benefits were demonstrated over the equivalent NPKS treatment (Treatment 5), the fungicide only treatment (Treatment 2), and the untreated control (Treatment 1).

The mean growth increases over the seven species from applying the STIMUL-8 treatments, compared with the NPKS control treatment, were as follows: rooting +13.7% (7-day STIMUL-8 applications) and + 11.9% (10-14 day STIMUL-8 applications); vigour +6.7% and +7.1%; plant biomass +7.0% and +7.9%; number of crowns or apical meristems +18.0% and +23.6%; number of flower stems +16.0% and +26.1%.

Table 3. Effect of STIMUL-8 applied pre-tipping to *Fragaria xananassa* mother plants upon growth of subsequent runners – Year 2001 Trial.

<i>Fragaria xananassa</i> 'Elsanta' (g F.W. of 12 plants)			
(A)	(B)	(C)	
	2 litres·ha ⁻¹ applied 5 days before tipping	STIMUL-8 2 litres·ha ⁻¹ applied 10 and 5 days before tipping	STIMUL-8 Increase (%) of (C) over (A)
3 October 2001			
Plant wt (including roots)	86	98	+14.0%
Root wt	36	46	+27.8%
Plant wt (excluding roots)	56	53	-5.4%
29 October 2001			
Plant wt (including roots)	160	204	+27.5%
Root wt	66	90	+36.4%
Plant wt (excluding roots)	94	114	+21.3%

Table 4. Effect of STIMUL-8 application on growth attributes of *Viola* (pansy) during propagation Year 2002 Trial.

Treatment	Rooting	Vigour	Biomass	Number of crowns/meristems	Number of flower stems
Untreated (no fungicides or added fertiliser).	4.4a	5.8a	6.2a	1.2a	2.2a
Fungicide control treatment (no added fertiliser).	4.2a	6.4a	6.4a	1.0a	3.0a
STIMUL-8 applied every 7 days from 1-leaf stage (+ fungicide treatments of (2) above).	5.0b	6.8b	7.2bc	1.2a	3.2a
STIMUL-8 applied every 14 days from 1-leaf stage (+ fungicide treatments of (2) above).	4.8ab	6.6ab	7.6c	1.4a	4.8b
NPKS fertiliser (v similar to STIMUL-8) applied every 7 days from 1-leaf stage (+ fungicide treatments of (2) above).	4.6ab	6.2a	6.6ab	1.4a	2.6a
LSD (P = 0.05)	0.60	0.91	0.97	0.58	1.13
LSD (P = 0.01)	0.83	1.26	1.34	0.81	1.56

Table 5. Effect of STIMUL-8 application on growth attributes of *Helichrysum petiolare* during propagation Year 2002 Trial.

Treatment	Rooting	Vigour	Biomass	Number of crowns/meristems	Number of flower stems
Untreated (no fungicides or added fertiliser).	4.8a	4.8a	4.8a	2.4a	2.4a
Fungicide control treatment (no added fertiliser).	5.6bc	4.8a	4.6a	2.4a	2.4a
STIMUL-8 applied every 7 days from 1-leaf stage (+ fungicide treatments of (2) above).	6.2c	5.4b	5.6b	3.0b	3.0b
STIMUL-8 applied every 14 days from 1-leaf stage (+ fungicide treatments of (2) above).	5.4ab	5.4b	5.2ab	3.2b	3.2b
NPKS fertiliser (nutrient content close to STIMUL-8) applied every 7 days from 1-leaf stage (+ fungicide treatments of (2) above).	5.4ab	4.6a	5.0ab	2.2a	2.2a
LSD (P = 0.05)	0.75	0.52	0.66	0.62	0.62
LSD (P = 0.01)	1.03	0.72	0.91	0.86	0.86

Table 6. Effect of STIMUL-8 application on growth attributes of *Begonia* F1 hybrid 'Nonstop Rose Petticoat' Year 2002 Trial.

Treatment	Rooting	Vigour	Biomass	Number of crowns/meristems	Number of flower stems
Untreated (no fungicides or added fertiliser).	4.0a	4.8a	5.0a	1.8a	2.4a
Fungicide control treatment (no added fertiliser).	4.8b	4.8a	5.2ab	2.0a	2.4a
STIMUL-8 applied every 7 days from 1-leaf stage (+ fungicide treatments of (2) above).	5.4b	5.4a	5.6b	2.6ab	3.6c
STIMUL-8 applied every 14 days from 1-leaf stage (+ fungicide treatments of (2) above).	5.2b	5.4a	5.6b	2.8b	3.6c
NPKS fertiliser (nutrient content close to STIMUL-8) applied every 7 days from 1-leaf stage (+ fungicide treatments of (2) above).	3.8a	5.0a	5.2ab	2.0a	3.2bc
LSD (P = 0.05)	0.78	0.91	0.58	0.69	0.66
LSD (P = 0.01)	1.08	1.25	0.79	0.95	0.90

Table 7. Effect of STIMUL-8 application on growth attributes of *Sedum spectabile* during propagation Year 2002 Trial.

Treatment	Rooting	Vigour	Biomass	Number of crowns/meristems	Number of flower stems
Untreated (no fungicides or added fertiliser).	4.8a	4.6a	4.2a	1.0a	1.4ab
Fungicide control treatment (no added fertiliser).	5.0a	4.6a	4.2a	1.0a	1.0a
STIMUL-8 applied every 7 days from 1-leaf stage (+ fungicide treatments of (2) above).	5.4a	5.4b	5.2b	1.4a	1.8b
STIMUL-8 applied every 14 days from 1-leaf stage (+ fungicide treatments of (2) above).	5.4a	5.4b	5.0ab	1.0a	1.8b
NPKS fertiliser (nutrient content close to STIMUL-8) applied every 7 days from 1-leaf stage (+ fungicide treatments of (2) above).	5.0a	5.2ab	4.6ab	1.4a	1.4ab
LSD (P = 0.05)	0.88	0.62	0.96	0.46	0.58
LSD (P = 0.01)	1.22	0.86	1.32	0.63	0.80

Table 8. Effect of STIMUL-8 application on growth attributes of *Geranium xcantabrigiense* 'Cambridge' during propagation Year 2002 Trial.

Treatment	Rooting	Vigour	Biomass	Number of crowns/meristems	Number of flower stems
Untreated (no fungicides or added fertiliser).	4.4a	6.2a	6.6a	1.2ab	0.8a
Fungicide control treatment (no added fertiliser).	4.8a	7.2ab	6.8a	1.0a	1.0a
STIMUL-8 applied every 7 days from 1-leaf stage (+ fungicide treatments of (2) above).	5.2a	7.4b	6.8a	1.8b	1.4a
STIMUL-8 applied every 14 days from 1-leaf stage (+ fungicide treatments of (2) above).	4.8a	7.4b	7.0a	1.8b	1.4a
NPKS fertiliser (nutrient content close to STIMUL-8) applied every 7 days from 1-leaf stage (+ fungicide treatments of (2) above).	4.6a	6.8ab	6.6a	1.0a	1.2a
LSD (P = 0.05)	1.03	1.04	0.72	0.66	0.66
LSD (P = 0.01)	1.42	1.43	1.00	0.91	0.91

Table 9. Effect of STIMUL-8 application on growth attributes of *Peiargonium* 'Red Mini Cascade' during propagation Year 2002 Trial.

Treatment	Rooting	Vigour	Biomass	Number of crowns/meristems	Number of flower stems
Untreated (no fungicides or added fertiliser).	5.0a	5.4a	5.0a	2.4a	3.8a
Fungicide control treatment (no added fertiliser).	5.2a	5.2a	5.0a	2.2a	3.2a
STIMUL-8 applied every 7 days from 1-leaf stage (+ fungicide treatments of (2) above).	4.6a	5.2a	5.2a	3.2b	4.2a
STIMUL-8 applied every 14 days from 1-leaf stage (+ fungicide treatments of (2) above).	5.2a	5.4a	5.0a	2.6ab	4.2a
NPKS fertiliser (nutrient content close to STIMUL-8) applied every 7 days from 1-leaf stage (+ fungicide treatments of (2) above).	4.4a	5.4a	5.0a	2.6ab	4.0a
LSD (P = 0.05)	0.93	0.61	0.45	0.73	0.98
LSD (P = 0.01)	1.29	0.85	0.63	1.01	1.35

Table 10. Effect of STIMUL-8 application on growth attributes of *Plectranthus variegatus* during propagation Year 2002 Trial.

Treatment	Rooting	Vigour	Biomass	Number of crowns/meristems	Number of flower stems
Untreated (no fungicides or added fertiliser).	4.6a	6.4a	4.8a	1.0a	1.8a
Fungicide control treatment (no added fertiliser).	4.0a	6.6ab	4.8a	1.0a	1.6a
STIMUL-8 applied every 7 days from 1-leaf stage (+ fungicide treatments of (2) above).	5.2a	6.8ab	4.8a	1.0a	1.6a
STIMUL-8 applied every 14 days from 1-leaf stage (+ fungicide treatments of (2) above).	5.6a	7.0b	5.4a	1.0a	1.6a
NPKS fertiliser (nutrient content close to STIMUL-8) applied every 7 days from 1-leaf stage (+ fungicide treatments of (2) above).	5.0a	6.6ab	4.8a	1.0a	1.8a
LSD (P = 0.05)	0.68	0.54	0.65	-	0.75
LSD (P = 0.01)	0.94	0.73	0.90	-	1.03

It is postulated that the enhanced growth achieved by STIMUL-8 (i.e., the synergistic rooting and above-ground benefits of the mixture) is partly due to increased stimulation of the plant's hormonal system — and in particular increased natural auxins in the stems which increase root initiation (Wightman et al, 1980). In turn, this may result in the root's increased synthesis of natural cytokinin hormones, with the new balance between auxins and cytokinins adjusting the plant's root:shoot ratio, causing increase in both rooting and above-ground biomass. Although apical dominance (e.g., lateral bud inhibition) is increased by auxins, the presence of increased natural cytokinins would counteract this, as would appear in these trials (Sachs and Thimann, 1964; Sachs and Thimann, 1967; for the cytokinin-auxin balance hypothesis; Williams and Cartwright, 1980).

The hypothesis of initial raised-plant-auxin levels would be consistent with the results shown in Table 3, which show that application of STIMUL-8 to strawberry mother plants prior to tipping markedly increased root and shoot growth of the subsequent runner plants — analogous to the foliar application of a hormone rooting powder, but stimulated via the plant itself.

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