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CONTENTS

PRACTICAL SECTION FOR GROWERS

Objectives and background

Although improved production techniques implemented in recent years have led to significant improvements in the quality of liners, growth control remains a problem with some species, especially under protection. The efficacy of chemical plant growth regulators (PGRs) on a range of hardy nursery stock was demonstrated in earlier work (HNS 39 and HNS 39a), but this work was confined to plants potted into their 'final' pot size, with PGR treatments applied after pinching/pruning to form a good branch framework.

The objective of this project, HNS 39b, was to evaluate the potential of various PGRs, applied at several rates and to different stages of growth, on liners of a range of hardy nursery stock (HNS) species, with the aim of producing more compact growth and improving plant quality.

Work in the first year of this project looked at effects of foliar sprays of three PGRs (B-Nine, B-Nine + New 5C Cycocel, Bonzi), on the growth and quality of rooted cuttings and liners of several hardy nursery stock subjects. Results showed conclusively that PGR treatments, applied to plants in the plug tray and/or after potting-on, had little or no effect on influencing shoot number, and that a programme of soft pinches was essential to produce a good branch framework before their application. The effect of the PGRs on subsequent growth was disappointing with, generally, only the higher rates of Bonzi (25 ml or 50 ml/litre) producing any marked reduction in shoot length.

In view of these results, in Year 2, rooted cuttings were pinched in the plug trays and PGR treatments were not applied until after potting, when 2 foliar sprays of each treatmemt were given, the first applied as new shoot growth started, the second a fortnight later. The range of PGRs used was the same as in Year 1, with three rates of B-Nine (3 ml, 6 ml or 9 ml/litre), one of the B-Nine + New 5C Cycocel (6 ml + 3 ml/litre respectively), and four rates of Bonzi (1 ml, 10 ml, 25 ml or 50 ml/litre).

Summary of results

This was the second year of a three year project, and results were encouraging in that use of PGRs showed promise for manipulating plant growth to produce more compact, quality liners under protection. PGR strategies still need to be developed before guidelines/recommendations can be given, but the following points can be made.

- The primary branch framework must be developed by appropriate pinching/trimming techniques before PGRs are applied, since they do not appear to influence number of shoots produced.

- Two applications of PGRs post potting in the second year achieved a marked effect in reducing growth, unlike the first year where a single application only produced a limited response.

- Stage of growth at the time of PGR application was important, with their application needed as shoots started to extend. The crop also needs to be as uniform as possible at time of application for the most effective response to PGRs to be achieved.

- Response to PGRs varied with species.

  * Those responding to ***B-Nine*** (6-9 mls/litre) included *Berberis*, *Buddleia*, *Lavandula* and *Lonicera*.

  * Those particularly sensitive to ***Bonzi*** (25-50 mls/litre) were *Ceanothus*, *Escallonia*, *Photinia* and *Viburnun*.

  * *Choisya* and *Pyracantha* responded to both ***B-Nine*** and ***Bonzi***.

  * All species in the trial proved responsive to a tank mix of ***B-Nine + New 5C Cycocel*** (6 mls/litre + 3 mls/litre respectively), though further work on rates of the two PGRs in combination is required, as some of the growth checks were considered excessive.

- Use of the PGRs was often accompanied by an increase in intensity of foliage colour.

- Mode of action of B-Nine and Cycocel was quick with effects of application showing shortly after application, whereas effects of Bonzi took several weeks to become apparent.

- The different mode of action of the PGRs, and rates, needs to be considered in developing various strategies for achieving the growth control required, whether it be 1-2 applications at the start of the growth, or increased frequency of application over time at lower rates. The latter strategy would be particularly appropriate for the faster acting, less persistent PGRs, providing greater control of crop management, with less risk of overdosing. This needs further investigation.

- Further work is also required to monitor persistence of the PGRs, particularly Bonzi, to ensure that subsequent growth when potted-on is not adversely affected.

- In addition, whether PGRs have any effect on rooting of cuttings taken from treated plants needs monitoring, since production container plants are often used as a source of cuttings.

MATERIALS AND METHODS

PGR Treatments (2 foliar sprays applied at approximately 14 day intervals)

i. B-Nine at 3 ml/litre
ii. B-Nine at 6 ml/litre
iii. B-Nine at 9 ml/litre
iv. B-Nine at 6 ml/litre plus chlormequat as New 5C Cycocel at 3 ml/litre
v. Bonzi at 1 ml/litre
vi. Bonzi at 10 ml/litre
vii. Bonzi at 25 ml/litre
viii. Bonzi at 50 ml/litre
ix. Untreated control

All PGRs were applied at pH 6.5, as foliar sprays to just before the point of run off, when new growth was 5-15 cm long, depending on species. Screens were used to protect plants in adjacent plots from spray drift during applications.

Treatment dates: *Pyracantha*: 3 April, 15 May 1998
Other species: 1 May, 15 May 1998

Species

Berberis thunbergii 'Kelleriis'
Buddleia davidii 'Empire Blue'*
Ceanothus griseus 'Yankee Point'
*Choisya ternata**
Escallonia 'Donard Radiance'
Lavandula angustifolia 'Hidcote'
Lavandula stoechas 'Marchwood'
Lonicera japonica 'Halliana'
Photinia x fraseri 'Red Robin'
Pyracantha 'Red Column'
*Viburnum tinus**
Vinca minor 'Atropurpurea'

* Clonal material of these species was used from HRI Efford stock beds.
Unrooted cuttings of the remaining species were bought in from a commercial supplier.

Design: Unreplicated observation with up to 20 cuttings of each species per treatment.

Cultural details

***Propagation*:** Cuttings were struck in a 50:50 peat:fine pinebark (Cambark) mix in QP77 plug trays under mist until early October, and under low polythene covers thereafter. When roots were visible at the base of the plugs, the module trays were weaned under frost protected glass. During propagation, a 14 day programme of alternating sprays of dichlofluanid (Elvaron), benomyl (Benlate), iprodione (Rovral) and prochloraz (Octave) was applied.

***Potting-on*:** Weaned rooted plugs were potted on into 90 mm pots using a peat based growing media containing controlled release fertiliser (Osmocote Plus 12-14 Autumn), at rates appropriate to species. After potting, plants were grown on under frost protected glass (until early April) and thereafter under polythene structures with netting sides, on sand beds irrigated by seep hose laid on the surface.

Propagation and potting dates for each species are detailed in the Results section.

***Pinching*:** Cuttings were pinched in the plugs prior to potting in order to establish a reasonable primary branched framework prior to the application of PGR treatments after potting.

Assessments

Final records were taken at the end of June 1998.

The following records were taken:-

i. crop diary
ii. plant height (mm or cm, depending on species) or length of longest shoot for *Vinca*
iii. number of shoots/plant
iv. average length of new shoots (*Berberis,, Choisya* and *Photinia* only)
v. foliage colour score (5 = dark green, 1 = pale green)
vi. number of plants with buds/open flowers (if applicable)
vii. chlorosis score (2 = chlorosis clearly present, 0 = no chlorosis)
viii. photographic record of growth (see Appendix)

RESULTS

***Berberis thunbergii* 'Kelleriis'** (Tables 1-2, Plates 1-2 in Appendix)

Rooted cuttings in plugs were brought in from a commercial supplier in February 1998, and potted on shortly after receipt.

This species proved relatively sensitive to all three PGRs used.

The greatest control of shoot length was achieved with the tank mix of B-Nine + New 5C Cycocel, closely followed by the higher rates of B-Nine (9 ml/litre) and Bonzi (25-50 ml/l) (Table 1). This control appeared to be at the expense of number of shoots growing away from the pinched plant, with a higher proportion of plants receiving PGRs failing to meet the 3+ break specification, compared with the untreated controls.

There was some variability in plant response within treatment, with some plants within a PGR plot apparently unaffected by the application of PGRs, others responding strongly. This, in part, could be due to the stage of shoot growth at time of PGR application, with those more advanced in growth less affected by treatment. Nevertheless, Table 2, which shows the shoot length distribution within each treatment, clearly shows the increase in proportion of shorter length shoots in response to PGRs. This is most evident with shoots 2-3, and particularly in relation to suppression of shoots growing away.

Whilst this species is responsive to PGRs, care will be needed to ensure that a good primary framework is produced by hand pinching before considering use of PGRs. However, the positive response of this species to PGRs suggests that they could have a place here in helping to reduce excessive extension growth, thus helping to produce better quality, more compact plants without the need for additional trimming. Further work is required to develop the best method of use, stage of growth applied and PGR formulation, rate and number of applications. This is explored further in the overall discussion section.

Table 1: ***Berberis thunbergii*** **'Kelleriis': growth records taken late June 1998**

(20 plants/plot)

Treatment (2 foliar sprays)	Average plant height (cm)	% Plants with 3+ shoots	Average no. of shoots/plant	Average shoot length/plant (cm)	Average length of longest shoot (cm)
Untreated	17.2	84	3.7	9.3	11.2
B-Nine 3 ml/litre	16.0	37	2.1	11.2	12.4
B-Nine 6 ml/litre	15.4	32	2.0	10.2	11.4
B-Nine 9 ml/litre	13.5	21	1.9	7.8	8.5
B-Nine 6 ml/litre + New 5C Cycocel 3 ml/litre	10.9	21	1.4	7.6	7.7
Bonzi 1 ml/litre	19.6	63	3.2	11.1	15.0
Bonzi 10 ml/litre	19.2	47	2.5	10.2	14.5
Bonzi 25 ml/litre	13.2	5	1.3	8.3	9.7
Bonzi 50 ml/litre	13.5	10	1.6	9.0	9.2

Table 2: ***Berberis thunbergii*** **'Kelleriis': shoot length distribution expressed as % of plants within the different categories** (20 plants/plot)

Treatments	Shoot length category (cm)						
	0	<5	5-10	10-15	15-20	20-30	>30
Shoot 1							
Untreated	0	30	45	25	0	0	0
B-Nine 3 ml/l	10	26	37	5	0	11	11
B-Nine 6 ml/l	11	32	42	0	5	5	5
B-Nine 9 ml/l	5	35	45	5	0	10	0
B-Nine + New 5C Cycocel	26	47	11	11	0	5	0
Bonzi 1 ml/l	0	16	47	21	5	0	11
Bonzi 10 ml/l	6	26	42	26	0	0	0
Bonzi 25 ml/l	15	20	40	10	5	10	0
Bonzi 50 ml/l	11	7	61	0	11	0	0
Shoot 2							
Untreated	10	15	55	10	10	0	0
B-Nine 3 ml/l	32	21	26	16	0	5	0
B-Nine 6 ml/l	37	21	32	5	5	0	0
B-Nine 9 ml/l	40	20	40	0	0	0	0
B-Nine + New 5C Cycocel	68	16	5	0	11	0	0
Bonzi 1 ml/l	5	21	53	5	5	0	11
Bonzi 10 ml/l	16	0	53	16	0	5	10
Bonzi 25 ml/l	65	5	30	0	0	0	0
Bonzi 50 ml/l	50	0	22	22	6	0	0
Shoot 3							
Untreated	20	15	40	20	5	0	0
B-Nine 3 ml/l	63	10	0	11	16	0	0
B-Nine 6 ml/l	69	0	16	5	0	5	5
B-Nine 9 ml/l	80	10	10	0	0	0	0
B-Nine + New 5C Cycocel	80	5	10	0	5	0	0
Bonzi 1 ml/l	37	11	32	5	10	5	0
Bonzi 10 ml/l	53	5	26	11	0	5	0
Bonzi 25 ml/l	95	0	0	5	0	0	0
Bonzi 50 ml/l	88	0	6	6	0	0	0
Shoot 4							
Untreated	40	5	30	15	5	5	0
B-Nine 3 ml/l	89	0	0	0	0	11	0
B-Nine 6 ml/l	90	0	5	0	0	5	0
B-Nine 9 ml/l	85	0	5	5	0	5	0
B-Nine + New 5C Cycocel	95	5	0	0	0	0	0
Bonzi 1 ml/l	74	0	16	10	0	0	0
Bonzi 10 ml/l	84	0	16	0	0	0	0
Bonzi 25 ml/l	100	0	0	0	0	0	0
Bonzi 50 ml/l	94	0	0	6	0	0	0

***Buddleia davidii* 'Empire Blue'** (Table 3, Plates 3-4 in Appendix)

Cuttings were struck in early August 1997 and potted on in February 1998.

This species broke away very poorly from the pinch in the plug, and without further trimming produced plants of very poor, straggly quality with only 1-2 breaks (Plates 3-4). Nevertheless, it was still possible to gauge the plants' response to PGRs.

The tank mix of B-Nine + New 5C Cycocel produced the most marked reduction in growth, closely followed by B-Nine at the higher rate (9 ml/litre). In addition, foliage colour was a darker green in these two treatments, but especially in the B-Nine + New 5C Cycocel mix. However, there was an indication of a delay in flowering in these treatments, and again especially in the B-Nine + New 5C Cycocel plots, since although bud initiation appeared unaffected, number of open flowers at final assessment was less here.

Bonzi sprays appeared largely ineffective in controlling growth of this species at the rates applied, with only a small reduction in height observed at the highest rate (50 ml/litre), where foliage colour was also darker.

All plants had some chlorosis on older leaves, but there was evidence of additional chlorotic spotting and some marginal chlorosis on a number of plants in the B-Nine + New 5C Cycocel treatment.

The response seen with *Buddleia davidii* 'Empire Blue' to B-Nine and B-Nine + New 5C Cycocel in this trial, was more marked than that observed in Year 1 of the work. This could be the result of applying two sprays this year instead of a single application as in Year 1. Based on these results it is worth considering further work to refine PGR applications with *Buddleia* to provide an effective tool in helping to improve quality of the liner stage, once the primary branch framework has been developed.

Table 3: ***Buddleia davidii*** **'Empire Blue': growth records taken late June 1998**

(20 plants/plot)

Treatment (2 foliar sprays)	Average plant height (cm)	Average no. of shoots/plant	Foliage colour score*	% plants with flower buds	% plants with open flowers
Untreated	91.0	1.9	2.1	90	65.0
B-Nine 3 ml/litre	62.1	1.6	2.3	85	30.0
B-Nine 6 ml/litre	55.8	1.9	2.6	90	15.0
B-Nine 9 ml/litre	48.5	1.7	3.3	100	15.0
B-Nine 6 ml/litre + New 5C Cycocel 3 ml/litre	41.5	1.9	4.5	100	5.0
Bonzi 1 ml/litre	80.4	1.8	1.8	80	50.0
Bonzi 10 ml/litre	81.0	2.2	2.6	90	30.0
Bonzi 25 ml/litre	85.2	2.0	2.5	85	30.0
Bonzi 50 ml/litre	75.5	2.1	3.2	80	60.0

* Foliage colour score 5 = dark green
1 = pale green

***Ceanothus griseus* 'Yankee Point'** (Table 4, Plates 5-6 in Appendix)

Cuttings were struck in September 1997 and potted on in February 1998.

As found in previous work (HNS 39/39a), *Ceanothus* proved particularly responsive to Bonzi, with plant height decreasing as the rate of PGR increased (Plate 6). However, the growth restriction achieved at the 25-50 ml/litre rate of Bonzi applied twice was considered excessive (65%), in contrast to the more modest control achieved with a single application in 1997. It will also be important to monitor persistence of the Bonzi treatments, since work with the finished plants under HNS 39 demonstrated that effects could last into the following season, albeit that where this occurred, rates of Bonzi applied were higher than those used here (100-200 ml/ litre). A degree of persistence of the growth control into the next potting stage could, in fact, be beneficial in maintaining a balanced, quality growth structure. This needs further investigation.

Number of flower buds was increased in the Bonzi treatments, especially at the two higher rates, and these plants also had markedly darker green foliage than the untreated control plots.

The highest rate of B-Nine (9 ml/litre) gave a 40% reduction in growth, and darker foliage, compared with the untreated control, but had no effects on flowering.

As with other species, the tank mix of B-Nine + New 5C Cycocel had a more pronounced effect than B-Nine on its own, producing a 55% reduction in growth, enhancement of foliage colour equivalent to plants in the Bonzi treatments, and a small increase in flowering.

From the work to date *Ceanothus* has been shown to be one of the most sensitive HNS species to PGRs. Further work on refining rate and application(s) to match the growth response required could provide a useful tool for manipulating quality production of this genus, especially if a range of species responded in a similar manner to a single application rate.

Table 4: ***Ceanothus griseus*** **'Yankee Point': growth records taken late June 1998**

(20 plants/plot recorded)

Treatment (2 foliar sprays)	Average plant height (cm)	Average length of longest shoot per plant (cm)	Foliage colour score*	Average no. flower buds/plant
Untreated	56.3	27.5	1.7	0.0
B-Nine 3 ml/litre	47.5	23.8	2.2	0.0
B-Nine 6 ml/litre	45.8	25.3	2.4	0.0
B-Nine 9 ml/litre	33.3	16.9	3.3	0.1
B-Nine 6 ml/litre + New 5C Cycocel 3 ml/litre	24.7	8.5	4.7	1.1
Bonzi 1 ml/litre	39.5	16.2	3.5	1.7
Bonzi 10 ml/litre	36.9	13.8	3.7	1.3
Bonzi 25 ml/litre	20.6	6.6	5.0	3.7
Bonzi 50 ml/litre	19.6	4.5	4.6	5.0

* Foliage colour score 5 = dark green
1 = pale green

Choisya ternata (Tables 5-6, Plates 7-8 in Appendix)

Cuttings were rooted in early August 1997 and potted on in February 1998.

A high proportion of plants produced well branched liners with 3+ shoots.

Good growth control of this species was achieved with all three PGRs, with B-Nine and Bonzi proving equally effective, but the combination of B-Nine + New 5C Cycocel producing the greatest reduction in growth overall. In contrast to *Berberis*, little shoot development suppression as a result of PGR application was observed.

All rates of B-Nne produced reasonable growth control with a 32-39% reduction in plant height respectively as rates increased. This was also reflected in the average and longest shoot length compared to the untreated control, though here there was little difference between the rates of B-Nine used, suggesting that the lower shoots were longer than those at the apex. This is borne out by the shoot length distribution data in Table 6, where it can be seen that Shoot 1 is more markedly affected by B-Nine than Shoots 2, 3 or 4, where a higher proportion of plants have shoots in the 15-30 cm categories, compared with Shoot 1 which is mainly in the <5–15 cm lengths. Whether this was the result of the PGR being more effective in the tip of the plant, or due to difficulty in getting effective distribution of the spray to the lower shoots in plants spaced pot thick, requires further work.

Growth control with B-Nine + New 5C Cycocel was greater than B-Nine on its own, with a 50% reduction in height being achieved, and shoot length distribution in <5–15 cm categories. A degree of chlorosis occurred in this treatment, with 30% of the plants developing a patchy chlorosis 2-3 weeks after the second application, which was still obvious at the final assessment.

Bonzi sprays were also effective in controlling growth, with a 25-45% reduction in height achieved as rates increased from 1-9 ml/ litre. However, in contrast to B-Nine, these differences between concentration were also reflected in the average and longest shoot lengths per plant, though as with B-Nine, the greatest effect was observed on Shoot 1 at the apex of the plant, where a greater proportion of plants had shoots in the <5-15 cm categories. Chlorosis, similar in intensity and proportion of plants affected to that observed with B-Nine + New 5C Cycocel, was also seen where Bonzi was applied.

Some of the effects seen with *Choisya* may be considered excessive, but it was encouraging that this species, which can have severe internodal stretch under protection, was responsive to relatively low rates of PGRs. Further work to refine a PGR strategy for the crop is required.

Table 5: ***Choisya ternata*: growth records taken late June 1998**

(20 plants/plot recorded)

Treatment (2 foliar sprays)	Average plant height (cm)	% plants with 3+ shoots	Average no. of shoots/plant	Average shoot length/plant (cm)	Average length of longest shoot (cm)	Foliage colour score**	% Plants showing chlorosis †
Untreated	32.2	84	3.6	20.4	28.1	4.4	5 *
B-Nine 3 ml/litre	21.6	75	3.3	11.8	17.0	2.8	0
B-Nine 6 ml/litre	22.1	85	3.4	12.3	17.3	3.6	10 *
B-Nine 9 ml/litre	19.8	89	3.4	11.7	16.7	4.0	0
B-Nine 6 ml/litre + New 5C Cycocel 3 ml/litre	16.2	84	3.6	9.4	12.2	4.9	30 **
Bonzi 1 ml/litre	24.0	85	3.4	14.2	19.5	4.0	15 *
Bonzi 10 ml/litre	21.1	83	3.2	12.3	17.0	4.5	25 *
Bonzi 25 ml/litre	20.0	75	3.3	11.8	16.1	4.7	30 *
Bonzi 50 ml/litre	17.9	89	3.7	10.7	15.2	5.0	30 **

* Foliage colour score: 5 = dark green
1 = pale green

† Chlorosis * = slight
** = clearly present

Table 6: ***Choisya ternata*: shoot length distribution expressed as % of plants within the different categories** (20 plants/plot)

Treatments	Shoot length category (cm)						
	0	<5	5-10	10-15	15-20	20-30	>30
Shoot 1							
Untreated	0	0	11	47	11	21	10
B-Nine 3 ml/l	0	25	30	35	0	10	0
B-Nine 6 ml/l	0	20	45	20	15	0	0
B-Nine 9 ml/l	0	22	45	33	0	0	0
B-Nine + New 5C Cycocel	0	42	32	26	0	0	0
Bonzi 1 ml/l	0	25	40	15	15	5	0
Bonzi 10 ml/l	0	11	56	28	5	0	0
Bonzi 25 ml/l	0	15	25	50	5	5	0
Bonzi 50 ml/l	0	16	47	21	16	0	0
Shoot 2							
Untreated	0	0	5	21	11	37	26
B-Nine 3 ml/l	5	20	20	35	10	10	0
B-Nine 6 ml/l	0	5	10	40	30	15	0
B-Nine 9 ml/l	0	0	22	56	17	5	0
B-Nine + New 5C Cycocel	0	5	42	37	16	0	0
Bonzi 1 ml/l	0	0	30	45	5	20	0
Bonzi 10 ml/l	0	5	17	67	5	6	0
Bonzi 25 ml/l	0	5	25	50	20	0	0
Bonzi 50 ml/l	0	0	37	37	21	5	0
Shoot 3							
Untreated	16	11	5	16	5	37	10
B-Nine 3 ml/l	25	5	20	20	15	15	0
B-Nine 6 ml/l	15	0	40	30	5	10	0
B-Nine 9 ml/l	11	0	22	33	28	6	0
B-Nine + New 5C Cycocel	16	5	58	21	0	0	0
Bonzi 1 ml/l	15	0	15	10	35	25	0
Bonzi 10 ml/l	16	0	21	21	21	21	0
Bonzi 25 ml/l	25	10	20	20	15	10	0
Bonzi 50 ml/l	11	10	47	16	16	0	0
Shoot 4							
Untreated	37	0	5	0	16	37	5
B-Nine 3 ml/l	40	10	10	5	20	15	0
B-Nine 6 ml/l	50	0	10	30	0	10	0
B-Nine 9 ml/l	56	0	17	22	5	0	0
B-Nine + New 5C Cycocel	32	0	36	32	0	0	0
Bonzi 1 ml/l	50	0	5	15	0	30	0
Bonzi 10 ml/l	67	0	6	22	5	0	0
Bonzi 25 ml/l	55	5	5	20	10	5	0
Bonzi 50 ml/l	21	0	21	42	16	0	0

Escallonia **'Donard Radiance'** (Table 7, Plates 9-10 in Appendix)

Rooted cuttings in plugs were bought in from a commercial supplier mid February 1998 and potted shortly after receipt.

As in 1997 the greatest growth control (50%) was achieved using the higher rates of Bonzi (25 and 50 ml/litre), closely followed this year by the B-Nine/New 5C Cycocel tank mix, where a 43% reduction in height was recorded (Plate 9). Even the lower rates of Bonzi gave around an 18% reduction in height.

B-Nine alone appeared less effective with this species, though a 25% reduction in growth overall was recorded at the higher rate (9 ml/ litre).

All PGR treatments (especially the higher rates) produced plants with darker green foliage than the untreated controls, although some patchy chlorosis was recorded on plants treated with Bonzi and particularly the B-Nine + New 5C Cycocel tank mix.

Table 7: ***Escallonia*** **'Donard Radiance': growth records taken late June 1998**
(20 plants/plot)

Treatment (2 foliar sprays)	Average plant height (cm)	Average no. of shoots/plant	Foliage colour score**	% Plants showing chlorosis †
Untreated	51.7	4.4	2.2	0
B-Nine 3 ml/litre	42.7	3.8	2.8	0
B-Nine 6 ml/litre	46.0	4.3	3.9	0
B-Nine 9 ml/litre	38.1	4.0	4.2	0
B-Nine 6 ml/litre + New 5C Cycocel 3 ml/litre	29.4	4.5	4.7	95**
Bonzi 1 ml/litre	39.8	4.4	3.0	10*
Bonzi 10 ml/litre	45.0	4.2	3.2	5*
Bonzi 25 ml/litre	23.4	4.6	4.3	60*
Bonzi 50 ml/litre	22.3	4.8	4.7	5*

** Foliage colour score: 5 = dark green, 1 = pale green
† Chlorosis * = slight, ** = clearly present

Use of PGRs to produce more compact quality plants of *Escallonia* appears feasible, results obtained this year confirming those observed in the first year. However the PGR strategy to be adopted needs further work to ensure that growth does not become too compact, or persist overlong in the next potting stage.

***Lavandula angustifolia* 'Hidcote'** (Table 8, Plates 11-12 in Appendix)

Cuttings were struck in early August 1997 and potted in February 1998.

Influence of PGRs on Lavender were more marked this season, compared with the limited response achieved in the first year with *Lavandula angustifolia* 'Alba'.

Low rates of B-Nine had minimal effect, but at 9 ml/litre height of the vegetative growth was reduced by 40%, compared with the untreated controls. However, length of the flower stem was reduced progressively as rate of B-Nine increased, with a 9%, 15% and 48% reduction in length respectively. There was also a 25% increase in flowers/buds/plant at the two higher rates of B-Nine.

A similar result to the 9 ml/litre B-Nine was observed with the B-Nine + New 5C Cycocel tank mix.

In direct contrast to results obtained with *Lavendula angustifolia* 'Alba' in 1997, Bonzi had no obvious effect in reducing plant growth of *Lavendula angustifolia* 'Hidcote' this season, despite two applications being given, compared with the single application in the previous trial.

The higher rates of B-Nine (6 ml, 9 ml/litre) and the B-Nine + New 5C Cycocel tank mix appeared to increase the number of flower buds/plant (or advance flowering). These treatments, together with the highest rate of Bonzi (50 ml/litre) also produced plants with noticeably darker foliage than other treatments.

There appears to be potential for the use of B-Nine and the B-Nine + New 5C Cycocel to produce more compact growth of *Lavendula angustifolia* cultivars, though further work on rates and timing of application, particularly with the B-Nine + new 5C Cycocel mix, which proved excessive at the rates used, will be required before recommendations can be made.

Table 8: *Lavandula angustifolia* **'Hidcote': growth records taken late June 1998**

(10 plants/plot)

Treatment (2 foliar sprays)	Average plant height to top pair of leaves (cm)	Average length of flower stem from top pair of leaves (cm)	Average no. of shoots/plant	Average no. of flower buds/plant	Foliage colour score*
Untreated	48.4	21.6	7.9	15.3	1.5
B-Nine 3 ml/litre	43.6	18.7	8.3	17.6	1.7
B-Nine 6 ml/litre	44.1	16.1	9.3	23.7	3.0
B-Nine 9 ml/litre	28.6	11.2	8.1	21.4	3.2
B-Nine 6 ml/litre + New 5C Cycocel 3 ml/litre	25.2	11.2	9.1	21.5	5.0
Bonzi 1 ml/litre	58.5	19.7	8.5	14.9	1.0
Bonzi 10 ml/litre	56.2	18.0	8.4	18.0	1.3
Bonzi 25 ml/litre	44.8	26.9	8.2	14.2	1.4
Bonzi 50 ml/litre	50.5	23.1	7.8	16.3	3.2

* Foliage colour score: 5 = dark green
1 = pale green

***Lavandula stoechas* 'Marchwood'** (Table 9, Plates 13-14 in Appendix)

Rooted cuttings in plugs were bought in from a commercial supplier in mid February 1998 and potted shortly after receipt.

While results with this species were essentially similar to those observed with *Lavandula angustifolia*, there was an indication that *Lavandula stoechas* might be more responsive to PGRs, since there was an influence of both Bonzi and the lower rates of B-Nine in reducing growth.

With B-Nine there was a successive reduction in average plant height of 33%, 46% and 57% as rates increased from 3 to 9 ml/litre.

The B-Nine + New 5C Cycocel mix produced similar results to the 9 ml/litre rate of B-Nine.

Bonzi, while less effective in controlling height compared to B-Nine or the B-Nine + New 5C Cycocel mix, nevertheless achieved a 30% reduction in plant height at the lowest rates, and a 37% reduction at the two higher rates. In addition, there was a marked increase in floral shoots with this PGR, particularly at the two higher rates (25-50 ml/litre).

All treatments, with the exception of the lowest rate of B-Nine, produced plants with darker foliage than the untreated controls, especially in the tank mix and higher rates of PGR.

As with *Lavandula angustifolia*, B-Nine, or the B-Nine + New 5C Cycocel mix, look particularly useful for achieving growth control of *Lavandula stoechas* liners.

Table 9: *Lavandula stoechas* 'Marchwood': growth records taken late June 1998
(18 plants/plot)

Treatment (2 foliar sprays)	Average plant height (cm)	Average no. of shoots/plant	Foliage colour score*	% Plants with floral shoots
Untreated	59.6	12.1	1.9	5
B-Nine 3 ml/litre	39.9	12.2	1.3	6
B-Nine 6 ml/litre	32.1	12.7	3.3	11
B-Nine 9 ml/litre	25.6	11.7	4.8	11
B-Nine 6 ml/litre + New 5C Cycocel 3 ml/litre	24.2	10.8	5.0	0
Bonzi 1 ml/litre	42.0	10.7	2.8	22
Bonzi 10 ml/litre	42.1	10.4	3.0	24
Bonzi 25 ml/litre	37.9	10.2	4.0	44
Bonzi 50 ml/litre	37.4	11.2	4.3	44

* Foliage colour score: 5 = dark green
1 = pale green

Lonicera japonica **'Halliana'** (Table 8, Plates 15-16 in Appendix)

Rooted cuttings in plugs were bought in from a commercial supplier in early February 1998 and potted shortly after receipt.

In direct contrast to the 1997 trial, where B-Nine appeared to have little influence in controlling growth of this species, it produced the most effective growth control in Year 2, with increasing rates from 3-9 ml/litre giving a reduction in length of growth of 17%, 22% and 27% respectively, which would have significantly reduced the amount of trimming required. B-Nine treatments also enhanced (or advanced) flowering, especially as rates increased, with 100% of plants floral at 9 ml/litre.

Effects of B-Nine + New 5C Cycocel mix were similar to B-Nine on its own at 9 ml/litre, but did cause some slight leaf chlorosis on all plants. As with B-nine, 100% of the plants were floral in the B-Nine + New 5C Cycocel treatment.

Sprays of Bonzi proved largely ineffective in controlling growth this season, and there was a marked increase in proportion of plants with chlorosis, compared with the untreated plots, as well as the chlorosis being more severe than observed on those sprayed with B-Nine + New 5C Cycocel mix.

Table 10: ***Lonicera japonica*** **'Halliana': growth records taken late June 1998**

(12 plants/plot, sample of 5 taken for fresh and dry weights)

Treatment (2 foliar sprays)	Average plant height (cm)	% Plants with flowers present	% Plants showing chlorosis †	Average fresh weight/ plant (g)	Average dry weight/plant (g)	% Dry matter
Untreated	150.3	42	27*	28.9	10.1	34.3
B-Nine 3 ml/litre	125.5	50	0	26.5	9.2	34.6
B-Nine 6 ml/litre	116.6	75	25*	29.3	10.4	35.5
B-Nine 9 ml/litre	94.3	100	0	23.2	8.3	35.3
B-Nine 6 ml/litre + New 5C Cycocel 3 ml/litre	102.6	100	100*	19.3	6.2	32.0
Bonzi 1 ml/litre	158.0	58	100**	27.4	8.9	32.2
Bonzi 10 ml/litre	151.2	67	83**	32.4	9.9	30.7
Bonzi 25 ml/litre	135.9	75	75**	31.3	9.9	31.5
Bonzi 50 ml/litre	145.6	75	83**	26.0	10.1	38.6

† Chlorosis score * = slight chlorosis
** = chlorosis clearly present

***Photinia x fraseri* 'Red Robin'** (Tables 11-12, Plates 17-18 in Appendix)

Cuttings were struck in August 1997, and potted on in February 1998.

As in 1997 this species proved more responsive to Bonzi and the B-Nine + New 5C Cycocel tank mix, than B-Nine on its own.

Effects of the lower rates of B-Nine were inconsistent, but there was evidence of a small response at 9 ml/litre concentration, where a 10% reduction in plant height was recorded.

The B-Nine + New 5C Cycocel mix reduced plant height by almost 50%, which was also reflected in the average and longest shoot length data.

With Bonzi there was a successive reduction in plant height/shoot length as concentration increased from 1 ml/litre through to 25 ml/ litre. Increasing the rate applied to 50 ml/litre gave no further controls of growth. Overall 1 ml/litre Bonzi sprayed on the two occasions gave around a 30% reduction in growth, while 25 ml/litre achieved almost a 60% reduction.

There was considerable variability in plant to plant response within treatments, as shown in the proportions of plants within each shoot length categories (Table 12). As with the other species assessed in this manner (*Berberis, Choisya*), this was felt to be due to the variability in stage of growth of the young plant at time of treatment, since inevitably there would be a range of stages of shoot growth present. Nevertheless, the influence in B-Nine + New 5C Cycocel and Bonzi, particularly at 25 ml/ litre, in increasing the proportion of plants with more compact shoot lengths, can be seen.

The *Photinia* in this trial only received a single pinch in the plug tray stage, and the number of breaks from this stop was relatively poor, with less than 50% of the plants developing 3 or more shoots. So while a reduction in internode length of this relatively straggly species is possible by using PGRs, care is needed to produce an adequate primary framework before applying them, since their use will not improve branching.

The potential for achieving a degree of growth control by use of PGRs to reduce internode length for this species looks promising, especially if this also produces a more balanced quality plant with shoots of equivalent length, rather than one shoot becoming dominant, as often occurs. Further work is required to develop the most effective strategy for PGR applications.

Table 11: ***Photinia x fraseri*** **'Red Robin': growth records taken late June 1998**

(20 plants/plot recorded)

Treatment (2 foliar sprays)	Average plant height (cm)	% Plants with 3+ shoots	Average no. of shoots/plant	Average shoot length/plant (cm)	Average length of longest shoot (cm
Untreated	40.8	45	2.4	24.4	36.4
B-Nine 3 ml/litre	34.0	25	2.1	24.8	32.2
B-Nine 6 ml/litre	39.3	35	2.1	28.2	38.1
B-Nine 9 ml/litre	31.9	50	2.6	20.2	27.5
B-Nine 6 ml/litre + New 5C Cycocel 3 ml/litre	21.6	35	2.5	13.7	19.3
Bonzi 1 ml/litre	28.9	10	1.8	20.3	27.0
Bonzi 10 ml/litre	26.0	45	2.4	16.7	23.0
Bonzi 25 ml/litre	17.5	35	2.2	10.8	15.2
Bonzi 50 ml/litre	18.1	30	2.1	10.4	15.5

Table 12 *Photinia x fraseri* 'Red Robin': shoot length distribution expressed as % of plants within the different categories (20 plants/plot)

Treatments	Shoot length category (cm)						
	0	<5	5-10	10-15	15-20	20-30	>30
Shoot 1							
Untreated	0	10	15	20	5	15	35
B-Nine 3 ml/l	0	10	20	15	10	35	10
B-Nine 6 ml/l	0	5	15	15	10	20	35
B-Nine 9 ml/l	0	55	10	15	10	15	0
B-Nine + New 5C Cycocel	0	15	30	30	10	15	0
Bonzi 1 ml/l	0	15	0	15	20	20	30
Bonzi 10 ml/l	0	20	10	20	15	30	5
Bonzi 25 ml/l	0	35	45	5	10	5	0
Bonzi 50 ml/l	0	25	30	15	10	20	0
Shoot 2							
Untreated	20	20	10	20	0	5	25
B-Nine 3 ml/l	20	0	5	5	10	15	45
B-Nine 6 ml/l	25	0	10	0	5	20	40
B-Nine 9 ml/l	0	15	10	5	10	30	30
B-Nine + New 5C Cycocel	25	15	15	20	5	20	0
Bonzi 1 ml/l	35	0	10	5	25	15	10
Bonzi 10 ml/l	15	10	25	20	10	20	0
Bonzi 25 ml/l	15	20	15	15	30	10	0
Bonzi 50 ml/l	25	30	20	10	10	5	0
Shoot 3							
Untreated	55	0	0	10	5	15	15
B-Nine 3 ml/l	75	0	0	5	0	15	5
B-Nine 6 ml/l	65	0	0	0	0	0	35
B-Nine 9 ml/l	50	5	5	0	15	15	10
B-Nine + New 5C Cycocel	65	0	20	10	5	0	0
Bonzi 1 ml/l	90	0	0	0	5	5	0
Bonzi 10 ml/l	55	5	0	0	20	20	0
Bonzi 25 ml/l	65	15	5	10	5	0	0
Bonzi 50 ml/l	70	10	10	5	0	5	0
Shoot 4							
Untreated	85	0	0	0	5	5	5
B-Nine 3 ml/l	100	0	0	0	0	0	0
B-Nine 6 ml/l	100	0	0	0	0	0	0
B-Nine 9 ml/l	90	0	0	0	0	5	5
B-Nine + New 5C Cycocel	70	0	0	0	25	5	0
Bonzi 1 ml/l	100	0	0	0	0	0	0
Bonzi 10 ml/l	85	0	5	0	5	5	0
Bonzi 25 ml/l	95	0	0	5	0	0	0
Bonzi 50 ml/l	100	0	0	0	0	0	0

***Pyracantha* 'Red Column'** (Table 13, Plates 19-20 in Appendix)

Cuttings were struck in September 1997 and potted in February 1998.

A single appplication of PGR post potting in 1997 had no obvious effect on plant growth of this species, but increasing to two applications in the second year (1998) produced a marked reduction in growth.

All rates of B-Nine produced more compact growth, with an 18, 30 and 35% reduction in average plant height as rates increased from 3-9 ml/litre.

Even greater control was achieved with B-Nine + New 5C Cycocel tank mix, where a 45% reduction in growth was recorded. There was also an indication of increased flowering with this treatment, with a higher proportion of plants carrying berries.

With Bonzi there was a successive reduction in overall plant height as rate of application increased from 10 ml/litre through to 50 ml/litre, where a final height reduction of 54% was recorded.

Foliage colour was a darker green in all PGR treated plants, compared with the controls, apart from Bonzi at 1 ml/litre which had not had any influence on growth either.

PGRs could provide a useful tool for this species to help keep growth under control, though perhaps not to the extent of some of the reductions achieved in this trial.

Table 13: ***Pyracantha* 'Red Column': growth records taken late June 1998**
(20 plants/plot)

Treatment (2 foliar sprays)	Average plant height (cm)	% plants with 3+ shoots	Average no. of shoots/plant	Foliage colour score*	% Plants with berry present
Untreated	51.8	45	2.6	1.2	10
B-Nine 3 ml/litre	42.7	50	2.5	3.0	0
B-Nine 6 ml/litre	36.5	50	2.9	3.2	10
B-Nine 9 ml/litre	34.1	60	2.6	3.5	15
B-Nine 6 ml/litre + New 5C Cycocel 3 ml/litre	28.5	50	2.5	4.2	25
Bonzi 1 ml/litre	49.4	25	2.0	1.6	10
Bonzi 10 ml/litre	40.9	45	2.5	3.6	5
Bonzi 25 ml/litre	34.2	65	2.8	4.7	0
Bonzi 50 ml/litre	24.0	85	3.4	4.6	10

* Foliage colour score: 5 = dark green
1 = pale green

Viburnum tinus (Table 14)

Plants rooted late in Year 1 were treated in Year 2.

This species appeared to be responsive to B-Nine + New 5C Cycocel and Bonzi.

B-Nine on its own had no apparent influence on average plant height or length of the longest side shoot, even at 9 ml/litre. However, when used in combination with New 5C Cycocel, a 20% reduction was achieved. Whether this was due to a synergistic effect of the B-Nine + New 5C Cycocel, or the Cycocel component itself needs further investigation. Foliage here was also darker than in the B-Nine or untreated plots.

Increasing rate of Bonzi gave successive reductions in growth of 14, 20, 26 and 30% respectively, and darker foliage compared with the untreated control.

Table 14: *Viburnum tinus*: growth records taken late June 1998
(10 plants/plot)

Treatment (2 foliar sprays)	Average plant height (cm)	% plants with 3+ shoots	Average no. of shoots/plant	Length of longest side shoot/plant (cm)	% Floral plants	Foliage colour score*
Untreated	27.3	40	3.4	16.5	30	1.2
B-Nine 3 ml/litre	35.4	30	2.3	23.9	0	1.0
B-Nine 6 ml/litre	30.9	20	2.0	22.0	20	1.4
B-Nine 9 ml/litre	26.5	40	2.4	17.8	0	1.9
B-Nine 6 ml/litre + New 5C Cycocel 3 ml/litre	21.8	50	3.9	10.8	20	3.4
Bonzi 1 ml/litre	23.5	55	3.8	13.3	11	3.4
Bonzi 10 ml/litre	21.8	40	2.8	11.9	20	4.0
Bonzi 25 ml/litre	20.3	20	2.7	10.7	22	3.2
Bonzi 50 ml/litre	19.3	27	3.0	9.5	36	4.8

* Foliage colour score: 5 = dark green
1 = pale green

Vinca minor **'Atropurpurea'** (Table 15)

Cuttings rooted in plugs were bought in from a commercial supplier in early February 1998 and potted shortly after receipt.

Vinca appeared more responsive to B-Nine and B-Nine + New 5C Cycocel, than Bonzi.

A 15% reduction in length of the longest shoots was achieved at the higher rates of B-Nine (6-9 ml/litre), though, overall, dry weight of the plants increased, suggesting sturdier growth. In addition, foliage colour intensified, and there was a marked increase in flowering.

Similar results were obtained with the B-Nine + New 5C Cycocel mix.

Bonzi had no effect on shoot length, though foliage colour was darker and a small increase in flowering occurred at the higher rates.

Table 15: ***Vinca minor*** **'Atropurpurea': growth records taken late June 1998**
(20 plants/plot)

Treatment (2 foliar sprays)	Average length of longest shoot/plant (cm)	% plants with flowers	Foliage colour score*	Average fresh weight/plant (g)	Average dry weight/plant (g)	% Dry matter
Untreated	44.0	20	3.7	10.1	2.5	23.9
B-Nine 3 ml/litre	40.0	100	2.4	9.7	2.7	27.2
B-Nine 6 ml/litre	37.7	70	4.2	11.0	2.9	26.1
B-Nine 9 ml/litre	37.1	70	4.7	11.2	3.0	26.7
B-Nine 6 ml/litre + New 5C Cycocel 3 ml/litre	34.6	85	4.7	9.8	2.6	26.4
Bonzi 1 ml/litre	44.7	37	3.8	9.7	2.5	26.0
Bonzi 10 ml/litre	48.1	45	4.4	11.7	2.7	23.2
Bonzi 25 ml/litre	43.7	60	4.7	12.5	3.4	26.9
Bonzi 50 ml/litre	42.2	55	4.5	10.6	2.8	25.7

* Foliage colour score: 5 = dark green
1 = pale green

Note – In Year 1 cuttings of *Berberis* x *ottawensis* 'Superba' and *Cytisus* 'Burkwoodii' did not root well and overwintered poorly, providing insufficiently good quality plants for recording in Year 2.

Although cuttings of *Pittosporum tenuifolium* 'Garnetti' rooted well in Year 1, few survived the winter and no reliable records could be taken in Year 2.

OVERALL DISCUSSION

This was the second year of a three year project with the objective of producing more compact growth and improving plant quality of liners through the use of plant growth regulators.

The first year's work clearly showed that PGRs would not replace the need for hand pinching to form the primary plant framework. In addition, response to a single application of PGR was limited, only the higher rates of Bonzi (25-50 ml/litre) providing any marked control of shoot growth. Consequently, in Year 2, rooted cuttings were pinched in the plug trays and PGRs applied post potting on two occasions.

The unreplicated design of the trial allowed a wider range of species to be considered than would otherwise have been practical. With the crop diversity and varied response across and within the different plant groups, it was felt important that as many species as possible be included to gain an overview of the potential of the PGRs for HNS liners. However, the number of plants included in each treatment was sufficient to ensure that effects observed could be attributed to the PGR applied.

The only specification for the liners at this stage was for 3+ breaks. This was achieved without difficulty for the naturally branching species (eg. *Escallonia, Lavandula*), but other species failed to reach this standard from the single pinch in the plug (e.g. *Buddleia*), and with others only a proportion of the plants reached the 3+ breaks standard required (e.g. *Photinia, Viburnum*). Consequently, further trimming after potting would have been necessary to produce the primary framework required prior to application of the PGRs. While this second pinch was not done in Year 2, results obtained did allow an assessment of the response of the plants to the various PGRs.

The effects of PGR applications were more marked in this the second year of the trial, with all species included responding in some way to one or all of the formulations used, indicating that two sprays were more effective than the single spray post potting in Year 1. However, detailed examination of the shoot length distribution data (*Berberis, Choisya, Photinia*), showed that some plants had hardly been affected by treatment, whilst others had a marked response. This inconsistent plant response was likely to have been due to variability in stage of shoot growth at the time of PGR application, since inevitably it would be difficult, if not impossible, to achieve this degree of uniformity in HNS crops. It does highlight the importance of applying the PGR to the crop with as high a proportion of plants at the correct stage of growth. This stage could vary with the different PGRs and rate of use, and more work is required to identify the most responsive stage of growth in the different species.

As expected from results of earlier work (HNS 39/39a), effectiveness of the PGR depended on species, with some more responsive to B-Nine (*Berberis, Buddleia, Lavandula, Lonicera*), others to Bonzi (*Ceanothus, Escallonia, Photinia, Viburnum*), and some responding to both (*Choisya,*

Pyracantha). However, all species in the trial proved responsive to the tank mix of B-Nine + New 5C Cycocel, and this appeared to be the most effective treatment in controlling growth overall. A summary of these effects is presented in Table 16.

In the absence of firm information, and in discussion with the Company, it was decided to use the middle rate of B-Nine (6 ml/litre) + a mid rate of Cycocel (3 ml/litre). This mix gave equally good growth control to B-Nine at 9 mls/litre for *Berberis*, *Buddleia*, *Lavandula* and *Lonicera*, but on occasion effects were greater with the tank mix than B-Nine alone (*Ceanothus*, *Choisya*, *Escallonia*, *Photinia*, *Pyracantha*, *Viburnum*), suggesting that there might be a synergistic effect of applying the two together. This will need confirming in future work by including Cycocel on its own for comparison. On the down side, the tank mix did cause a degree of foliage chlorosis with some species, but not where B-Nine was used on its own (*Choisya*, *Escallonia*).

The 25-30 ml/litre rates of Bonzi were generally more effective in reducing growth than the 1-10 ml/litre rates, and as observed with a number of species in HNS 39 (e.g. *Clematis*), there was also some evidence of flowering being advanced in *Lavandula* and *Ceanothus*. With *Lonicera* and *Vinca*, however, flowering was earlier with B-Nine, but somewhat later with *Buddleia*. This did not appear to be a reduction in numbers of flowers initiated, rather an advance/delay in flowers opening. Whether this was due to a faster/delayed initiation or development would require further study.

The degree of control achieved was often considered excessive, especially where treatments were most effective. This was particularly so for *Berberis thunbergii 'Kelleriis'* where some shoot supression was observed, but also with *Ceanothus*, *Choisya* and *Pyracantha*. With Lavender, while excessive growth control was seen with *L. angustifolia* 'Hidcote', equivalent treatments with *L. stoechus* 'Marchwood' produced quality plants, showing how response between species could vary. The control achieved with *Lonicera* was impressive, and would significantly reduce the amount of trimming required.

Thus, whereas one application post potting in Year 1 gave only a limited response, two applications in Year 2 proved excessive with some species. Further work is needed to fine tune the rate(s) and number of applications required, depending on height specifications. This will be especially important for the tank mix of B-Nine + New 5C Cycocel, since there is scope here to tailor the mix of the two products to achieve the response required for a wide range of species.

The mode of action of the PGRs used are quite different, with B-Nine and Cycocel producing an immediate response and being less persistent than Bonzi. Effects of Bonzi took 2-3 weeks to show and can be quite persistent. In this trial all PGRs were applied on the same date for both the first and second application. While this would be fine for B-nine and Cycocel, with Bonzi it would be easy to apply a second application too early before the results/benefits of the first application were visible. Nor was the persistence of Bonzi considered in this trial, but results from HNS 39, where finished plants were planted out in the field, showed that effects could last

well into the following season (*Ceanothus*). However, this occurred at rates of 100-200 ml/litre, rather than the 50 ml/litre used here. Nevertheless, it will be important to monitor persistence of the treatments in the subsequent container phase in future work. Some carry-over effect of growth control might well be an advantage in helping to maintain quality and balance of growth following establishment, but not at the expense of meeting growth specifications in the final pot stage.

Persistence will also be important factor to consider if plants previously treated with PGRs are to be used for stock, firstly in relation to the number and quality of cuttings produced, and secondly whether rooting is affected. This needs further investigation.

Future work needs to develop strategies for using PGRs to maximum effect for HNS liner production, and examine the potential for the PGR/rate over a range of species. Options could include:

- One or two applications at the correct stage of growth to provide the check required for the rest of the season.

- Successive applications of a lower rate of the appropriate PGR to enable management and changes in rate or frequency of the PGR during crop growth, depending on response observed, which may be influenced by other factors such as temperature. This already happens in Poinsettia production, where precise specifications for height are met by monitoring crop growth on a regular basis, and determining PGR requirements by comparing actual growth against the graphed ideal (Graphic Tracking). This degree of precision would not be feasible for HNS, with the wide range of species involved, but could follow the principle of 'little and often' to reduce internode extension, thus preventing excessive shoot elongation/stretching occurring, without over-controlling growth. It remains to be seen if this approach is effective.

Crop management to produce the primary framework of the plant as quickly as possible also needs addressing, since the PGRs used do not appear to have any influence on number of shoots developing (except supression where growth control was excessive, e.g. *Berberis*). Much of this can be achieved in the plug stage.

Thus this second year's work has demonstrated the potential of PGRs for checking growth of a range of HNS species under protection, where internode stretch can be a major problem (e.g. *Photinia*). Their use for manipulating growth to produce quality compact plants still requires further work to develop and fine tune strategies, but it was encouraging that the range of species used in this trial all responded positively to PGRs. The tank mix of B-Nine + New 5C Cycocel looked particularly promising for a wide range of species, though work on rates of the B-Nine + New 5C Cycocel combination is still required. An added benefit of PGR treatments was the increase in intensity of foliage colour associated with their use, further enhancing quality.

Table 16: Summary of growth control achieved by treatments

Species	B-Nine (ml/litre)			B-Nine + New 5C Cycocel tank mix	Bonzi (ml/litre)			
	3	6	9		1	10	25	50
Berberis thunbergii 'Kelleriis'	x	x	●●●	●●●	x	x	●●	●●
Buddleia davidii 'Empire Blue'	●●	●●	●●●	●●●	x	x	x	●
Ceanothus griseus 'Yankee Point'	○	○	●●	●●●	●●	●●	●●●	●●●
Choisya ternata	●●	●●	●●	●●●	●○	●●	●●	●●●
Escallonia 'Donard Radiance'	○	○	●	●●○	○	○	●●●	●●●
Lavandula angustifolia 'Hidcote'	●	●	●●●	●●●	x	x	x	x
Lavandula stoechas 'Marchwood'	●●	●●○	●●●	●●●	●○	●○	●●	●●
Lonicera japonica 'Halliana'	●○	●●	●●●	●●●	x	x	x	x
Photinia x fraseri 'Red Robin'	x	x	●	●●●	●○	●●	●●●	●●●
Pyracantha 'Red Column'	●	●●	●●	●●●	x	●	●●	●●●
Viburnum tinus	x	x	x	●●	●	●●	●●	●●
Vinca minor 'Atropurpurea'	x	●○	●○	●●	x	x	x	x

x no growth control achieved
○ slight response
● a small amount of growth control achieved
●● moderate growth control achieved
●●● marked growth control achieved

CONCLUSIONS

This was only the second year of a three year project, but results are encouraging in that use of PGRs show promise for manipulating plant growth to produce more compact, quality liners under protection. PGR strategies still need to be developed further before guidelines/ recommendations can be given, but the following points can be made.

- The primary branch framework must be developed by appropriate trimming techniques before PGRs are applied, since they do not appear to influence number of shoots produced.
- Two applications of PGRs post potting in the second year markedly reduced growth, unlike the first year where a single application only produced a limited response.
- Stage of growth at the time of PGR application was important, with their application needed as shoots started to extend. The crop also needs to be as uniform as possible at time of application for the most effective response to PGRs to be achieved.
- Response to PGRs varied with species.
  - * Those responding to ***B-Nine*** (6-9 mls/litre) included *Berberis*, *Buddleia*, *Lavandula* and *Lonicera*.
  - * Those particularly sensitive to ***Bonzi*** (25-50 mls/litre) were *Ceanothus*, *Escallonia*, *Photinia* and *Viburnun*.
  - * *Choisya* and *Pyracantha* responded to both ***B-Nine*** and ***Bonzi***.
  - * All species in the trial proved responsive to a tank mix of ***B-Nine*** + ***New 5C Cycocel*** (6 mls/litre + 3 mls/litre respectively), though further work on rates of the two PGRs in combination is required, as some of the growth checks were considered excessive.
- Use of the PGRs was often accompanied by an increase in intensity of foliage colour.
- Mode of action of B-Nine and Cycocel was quick with effects of application showing shortly after application, whereas effects of Bonzi took several weeks to become apparent.
- The different mode of action of the PGRs, and rates, needs to be considered in developing various strategies for achieving the growth control required, whether it be 1-2 applications at the start of the growth, or increased frequency of application over time at lower rates. The latter strategy would be particularly appropriate for the faster acting, less persistent PGRs, providing greater control of crop management, with less risk of overdosing. This needs further investigation.
- Further work is also required to monitor persistence of the PGRs, particularly Bonzi, to ensure that subsequent growth when potted-on is not adversely affected.
- In addition, whether PGRs have any effect on rooting of cuttings taken from treated plants needs monitoring, since container plants are often used as a source of cuttings.

Appendix