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HDC HNS42a

Lighting for alpines, heathers and Hardy Nursery Stock

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CONTRACT REPORT

LIGHTING FOR ALPINES, HEATHERS & HARDY NURSERY STOCK

Undertaken for HDC and EA Technology Ltd

1993/94

HDC Project No. HNS42a

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RELEVANCE TO GROWERS AND PRACTICAL APPLICATION

Application

Artificial lighting in glasshouses has been used for many years to programme the production of cut flowers and pot plants. However, it has only recently been considered in the UK for the manipulation of growth of hardy nursery stock. The objectives of the three years work carried out in this Project have been:

a) To determine the response of a range of alpine, heather, herbaceous and hardy nursery stock species to supplementary lighting,
b) To separate the effects of lighting throughout the hours of natural daylight, from those of photoperiod extension (to 16 and 22 hours), and
c) To identify areas of the industry where supplementary lighting may be of benefit.

Summary

During the winter months in the UK there is generally a shortfall of light which limits plant growth. Preliminary work at HRI Efford, initially funded by MAFF, indicated the potential benefits of supplementary lighting (in terms of improved growth and plant quality) on a range of *Pieris* and *Rhododendron* cultivars. Work in 1990/91 (jointly sponsored by MAFF and Electricity Association Technology Ltd) showed little benefit in providing minimum light levels greater than 2000 lux, from November to March, for a range of test subjects, including alpine species, heathers and ex-micropropagated *Rhododendron* cultivars. In 1991 a three year programme of work jointly funded through the HDC and EA Technology Ltd was undertaken, and using the experience gained in earlier work, a number of aspects of supplementary lighting were investigated.

Year 1: 1991/92: In this first year, a range of alpine, herbaceous, heather and hardy nursery stock species were grown in 16 or 22 hour photoperiods, in a minimum light intensity of 2000 lux (supplied by high pressure sodium lamps), and in natural daylight/daylength for varying lengths of time, between November and March. Two minimum air temperature regimes were used:

a) frost protection (+1°C), and
b) frost protection plus the estimated temperature lift from the lamps (+3-4°C), with ventilation at 19°C.

In both temperature regimes the quickest response was shown by the alpine species, with less than two weeks being long enough to promote growth with *Phlox* and *Sedum*, whilst 2-3 months were required for *Helianthemum*. Three to four weeks under lights was sufficient to advance both the growth and flowering period of *Armeria maritima* 'Splendens', *Campanula garganica* 'Blue Diamond', *C.* 'Resholt's Variety', *Thymus* 'Doone Valley', *T. serpyllum* 'Coccineus' and 'Bressingham Pink'.

Of the herbaceous species Lupin, *Primula auricula*, *P. japonica* and *Pulsatilla multifida* showed a significant response to lighting both in terms of earlier growth and earlier flowering, compared to plants grown in natural daylight/daylength. As with the alpines, a loss of quality rapidly occurred if plants were kept under lights for too long, particularly in the 'warmer' temperature regime.

The hardy nursery stock species, e.g. *Camellia* 'Debbie', 'E G Waterhouse' and 'Mattie Cole', *Skimmia japonica*, *Viburnum tinus*, generally took much longer to show any growth response. An exception was *Pieris japonica* 'Grayswood' where a month under lights was sufficient to stimulate a flush of growth, in both temperature regimes.

Newly weaned plantlets of four cultivars of *Rhododendron* ('Percy Wiseman', 'Sleepy', 'Surrey Heath' and 'Titian Beauty') in QP 150 modular trays responded well to the lighting treatments, with the most rapid growth occurring in the longest (22 hour) photoperiod and the 'warmer' temperature regime. Conventionally propagated liners of two of the three *R.* cultivars tested ('Betty Wormald' and 'Hoppy') responded well to supplementary lighting, although this applied only to plants which had been 'stopped' before introduction to the various treatments. The third cultivar 'Molly Miller' showed little if any response.

Rooted cuttings of a range of *Calluna vulgaris*, *Erica carnea*, *E. x darleyensis* and *E. vagans* cultivars potted into QP56 modular trays, all grew faster under lights (particularly in the 22 hour photoperiod) than in natural daylight/daylength, although the magnitude of the response varied with species/cultivar.

Carbon dioxide enrichment (to three times ambient level) used in combination with lighting was of no advantage to the growth of a number of hardy nursery stock species, including *Camellia* and *Rhododendron*.

Year 2: 1992/93: Separation of the effects of supplementary lighting throughout the hours of natural daylight, from those of photoperiod extension (to 16 hours) was investigated. High pressure sodium lamps were used to supply lighting for 8 hours (i.e. to supplement natural daylight), or for photoperiod extension to 16 hours, either alone or in combination with tungsten filament lamps. A much lower ventilation temperature (8°C) was used this year in an attempt to avoid the excessive internode length and associated loss of quality which occurred in the previous year's work. A range of test species were used including *Campanula*, *Dianthus*, *Azalea*, *Rhododendron*, *Pieris* and *Clematis* (the latter as potential 'stock' plants).

For all species, supplementary lighting supplied by high pressure sodium lamps throughout the hours of natural daylight (0800-1600 hours), gave only a relatively small improvement in growth/quality compared to the marked response achieved with photoperiod extension to 16 hours. Where high pressure sodium lamps were used to extend the photoperiod (2400-0800 hours) growth and quality were superior to that produced under tungsten filament lamps where growth became elongated/stretched, particularly on the alpine species. The best growth was produced by plants grown under high pressure sodium lamps throughout the entire 16 hour photoperiod (2400-1600 hours). The earlier growth on 'stock' plants of *Clematis* 'Miss Bateman' grown in a 16 hour photoperiod enabled cuttings to be taken earlier than from plants grown in an eight hour day.

In the first two years of work, young plants (i.e. rooted cuttings or ex-micropropagated plants in modular trays) or liners of heathers or hardy nursery stock subjects were almost exclusively used. However, the promising results achieved with plants of *Clematis* in 3 litre pots indicated a further area of production where lighting might be beneficial, namely for the manipulation of growth of stock plants, with a view to extending the propagation season (earlier or later), and increasing the number of cuttings produced by individual stock plants.

Year 3: 1993/94: In the final year of work investigations centred on stock plant manipulation, although the performance of *Rhododendron* liners bearing flower buds was also evaluated together with the potential of the plant growth regulant 'Bonzi' to reduce internode length on alpine species such as *Campanula* and *Dianthus*.

Stock plants of 8 *Calluna* and *Erica* species/cultivars and 5 *Clematis* cultivars were used as test subjects, and grown in 16 and 22 hour photoperiods or natural daylight/daylength. Photoperiod extension to 16 hours and more especially to 22 hours (using high pressure sodium lamps to provide a minimum light intensity of 2000 lux) resulted in more rapid regrowth on stock plants of four cultivars of *Calluna vulgaris* after a harvest of cuttings in early October 1993, yielding a sizeable second harvest in early February. However, the growth produced under lights was soft and with *Calluna vulgaris* 'Spring Glow' proved unsuitable for use as cuttings. More success may have been achieved if plants had been removed from lights and 'hardened off' in natural daylight, providing material for a strike of cuttings in March, still some 6-8 weeks earlier than plants grown in natural daylight throughout. Two cultivars of *Erica carnea* and *E. x darleyensis* responded more slowly, yielding fewer cuttings at the February harvest. Plants grown in natural daylight had made little regrowth by this time. Rooted cuttings from the October strike grown in 16 and 22 hour photoperiods from early February were significantly more advanced by April than those grown in natural daylight.

Early growth on some of the *Clematis* cultivars (e.g. 'Ernest Markham' and 'Jackmanii Superba') grown in the extended photoperiods resulted in a first strike of cuttings a month earlier than from plants grown in natural daylight.

The effect of lighting on the growth and flowering of budded *Rhododendron* liners was variable, producing earlier shoot growth on some plants, e.g. *R.* 'Snow Lady' and delaying flowering on others, e.g. *R. pemakoense*. The growth and flowering of *Campanula* 'White Clips' and *Dianthus* 'Joy' and 'Whatfield Gem' was markedly advanced by lighting. Foliar sprays of 'Bonzi' improved the compactness of *Campanula*, but had little effect on *Dianthus*.

Conclusions

To summarise, the main benefit of lighting for the range of species tested is associated with photoperiod extension to 16 or 22 hours. There appears to be little advantage to be gained from using a minimum light level higher than 2000 lux. High pressure sodium lamps produced the best quality plants, with 'stretching' occurring under tungsten filament bulbs. A 'cool' temperature regime is essential to maintain plant quality, although a slower response is achieved in these cooler temperatures. Plants must be transferred in natural daylight for several weeks to ensure that soft growth is 'hardened off'.

Lighting can only be regarded as one component in the management programme for producing a high quality product. Optimal conditions for the increased growth achieved earlier in the spring under lights must be provided by supplying adequate nutrition. For module raised material, careful watering is essential to prevent drying out. Alterations to the traditional husbandry timetable will be required to ensure that pinching/pruning and potting are carried out at the correct time, applicable. Modifications to the spray programme may be necessary to ensure control of pests such as Sciarid flies (which can build up rapidly under lights).

The work funded jointly through HDC and EA Technology Ltd over the past three years has identified a number of areas where lighting may be useful to the industry:

a) on 'finished' plants (primarily alpines, but also possibly some herbaceous species) for the advancement of growth and more importantly flowering, thereby extending the sales period for subjects which have their maximum sales appeal whilst in flower.

b) for the production of improved quality liners of 'high value' hardy nursery stock species (e.g. *Pieris*, *Rhododendron*), for the early spring markets.

c) for the establishment and growing on of both micropropagated material (e.g. *Rhododendron*) and rooted cuttings (e.g. heathers).

d) for advancement of growth of stock plants, providing material for earlier or 'out of season' strikes of cuttings, thereby extending the propagation season.

A number of 'knock on' benefits can also result:

i) more rapid growth of plants, allowing several batches of plants to be 'lit' in sequence, giving a greater output/season and making more efficient use of expensive facilities.

ii) increasing sales by producing quality material at a specified stage of growth outside the 'traditional' marketing period.

iii) easing labour peaks on the nursery by scheduling production of sequential batches of plants.

However, it must be remembered that lighting is an added cost in the production cycle, and the technique is not likely to be economically viable for all subjects, particularly those which are slow to respond. The advantages must be carefully weighed against the cost before investing in this additional management tool.

INTRODUCTION

Work jointly funded through the Horticultural Development Council and Electricity Association Technology Ltd since 1991/92 has investigated the effects of supplementary lighting during the winter months (November-March) on a range of alpine, heather, herbaceous and hardy nursery stock species.

Preliminary work established that there was little advantage in using a minimum light level of more than 2000 lux for the majority of the species tested. In 1991/92 the effect of differing lengths of photoperiod (16 hours and 22 hours) was examined, and the benefits of growing in extended photoperiods identified, for specific groups of plants. Treatments in 1992/93 aimed at separating the effects of lighting throughout the hours of natural daylight only, from those of photoperiod extension (using either high pressure sodium or tungsten filament lamps). Results showed little, if any, benefit from using supplementary lighting to supply a minimum light level of 2000 lux throughout the hours of natural daylight. In contrast, daylength extension to 16 and more particularly 22 hours resulted in a significant advancement of growth (and with the alpines, flowering) compared to plants grown in natural daylight, irrespective of the light source used. However, better quality plants with shorter internodes were produced under high pressure sodium lamps - since some 'stretching' occurred in the lower light levels under tungsten filament lamps. The importance of a 'low' air temperature regime coupled with supplementary lighting for the maintenance of quality was also identified.

In 1992/93 stock plants of two cultivars of *Clematis* were included as test subjects and earlier growth was stimulated on plants grown in extended photoperiods, allowing cuttings to be taken earlier in the year than from plants grown in natural daylight. Young plants of a range of heather cultivars also proved to be particularly responsive to lighting. The potential for lighting heather stock plants with a view to extending the propagation period was identified, together with that of improving the growth of rooted cuttings.

Even in a 'cool' air temperature regime, growth of certain groups of species, particularly alpines, grown under lights became soft with long internodes, leading to a loss of quality. In such cases the application of a growth regulator such as 'Bonzi' may be useful in reducing internode length and improving quality.

The emphasis of the work carried out this year concentrated on the use of supplementary lighting (to extend photoperiod) for manipulation of stock plant growth with a view to increasing the number of cuttings available and/or extending the propagation season. In addition, the use of lighting to advance the flowering/growth of budded liners of *Rhododendron*, and the use of growth regulators to improve the quality of alpines grown in extended photoperiods were also investigated.

OBJECTIVES

The work carried out in 1993/94 aimed to investigate the following:

a) extension of the propagation season for a range of species/cultivars of *Clematis* and **heathers** by lighting stock plants

b) improving the early growth of rooted heather cuttings

c) advancing the flowering period of budded liners of ***Rhododendron*** cultivars

d) improving the quality of *Campanula* and ***Dianthus*** plants grown under lights to advance flowering, by the use of growth regulators to reduce internode length

MATERIALS AND METHODS

Lighting treatments

a) 16 hour photoperiod*

b) 22 hour photoperiod*

c) natural daylight/daylength (control)

* respective photoperiods achieved using high pressure sodium lamps to supply a minimum light level of 2000 lux from mid October 1993 to end of March 1994.

Air temperature regime

minimum air temperature +2°C (i.e. frost protection)
venting at 8°C

Growing conditions

All plants were grown on ground level drained sand beds, with seephose irrigation.

Two glasshouse compartments were used for this work, with the two lighting treatments in a single compartment, separated by a central screen, and the natural daylight control in a separate compartment.

Species

a) **Heathers** (stock plants and rooted cuttings)

Erica carnea 'Myretoun Ruby'
Erica carnea 'Springwood Pink'
Erica x darleyensis 'Jack H Brummage'
Erica x darleyensis 'Ghost Hills'
Calluna vulgaris 'Blazeaway' (gold foliage)
Calluna vulgaris 'Spring Glow' (gold foliage)
Calluna vulgaris 'H E Beale'
Calluna vulgaris 'Kinlochruel'

Stock plants - see Figure 1 (page 9) for details of treatment.

Rooted cuttings - weaned rooted cuttings from the October strike were introduced to the lighting treatments in early February 1994.

Propagation regime

Rooting media:	75% Bulrush peat, 25% standard grade Perlite
Modular tray:	QP273
Hormone dip:	i) 500 ppm Synergol (5 second 'quick dip') ii) nil
Propagation environment:	low polythene tent (no mist) minimum temperature in growing media = 15°C
Time of cutting strike:	early October 1993 February 1994 (see Figure 1, page 9 for details)
Type of cutting taken:	this varied with species/cultivar, lighting treatment, and time of cutting strike. Details are given in Table 1, page 10.
Care of rooted cuttings:	when the majority of cuttings had rooted (i.e. when roots emerged from base of plugs), trays were removed from the propagation environment and 'hardened off' in a shaded glasshouse (heated to provide 'frost protection' only). Twice weekly applications of J Arthur Bowers Ericaceous feed commenced at this stage and continued until the cuttings were potted on.

Figure 1: Details of time of cutting strike of heathers in relation to lighting treatment

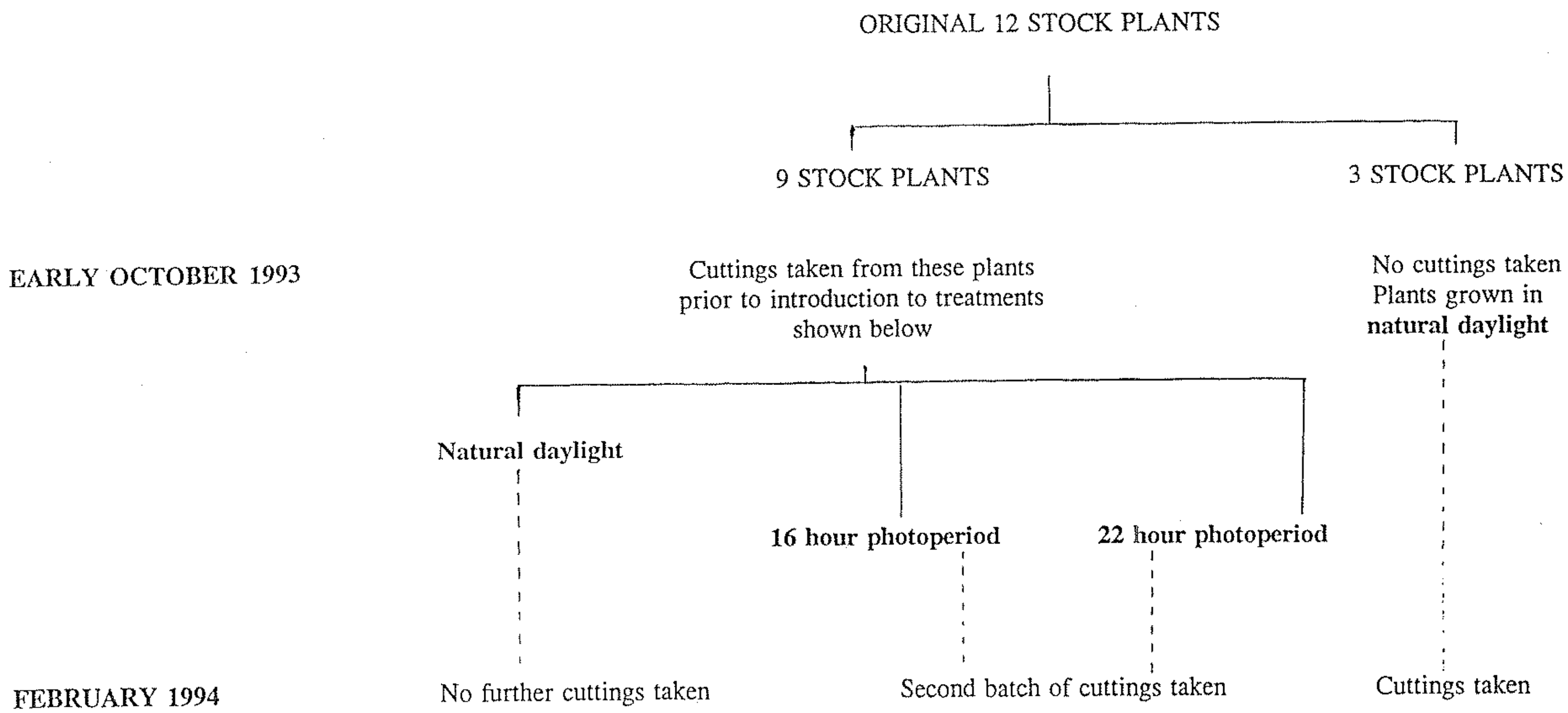


Table 1: Type of cutting taken according to species/cultivar, strike date and treatment

Species/cultivar	October strike (1993)	February strike (1994) Natural daylight	16 hour photoperiod	22 hour photoperiod
E. carnea 'Myretoun Ruby'	tops only	tops, bases	tops only	tops only
E. carnea 'Springwood Pink'	tops only	tops, bases	tops only	tops only
E.x darleyensis 'Jack H Brummage'	tops only	tops, bases	tops only	tops only
E.x darleyensis 'Ghost Hills'	tops only	tops, bases	tops only	tops only
C. vulgaris 'Blazeaway'	tops only	tops, bases	large, medium, small	tops, bases
C. vulgaris 'Spring Glow'	tops only	tops, bases	large, medium, small	tops, bases
C. vulgaris 'H E Beale'	tops only	tops, bases	large, medium, small	tops, bases
C. vulgaris 'Kinlochruel'	tops only	tops, bases	large, medium, small	tops, bases

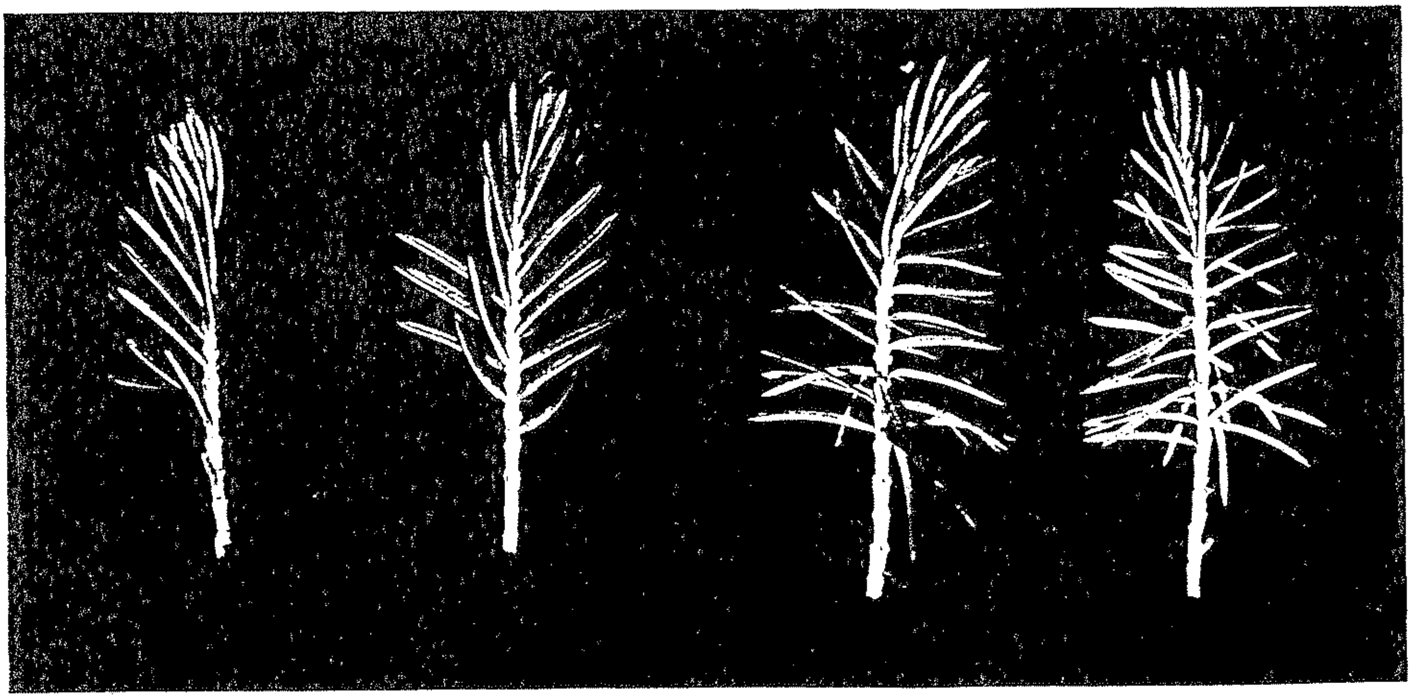
Illustrations of types of cuttings are shown in Plates 1-3, pages 11-13.

Plate 1: *Erica carnea* 'Springwood Pink'
Cutting types taken from plants grown under different lighting regimes in February 1994

Above: Natural daylight

Tops

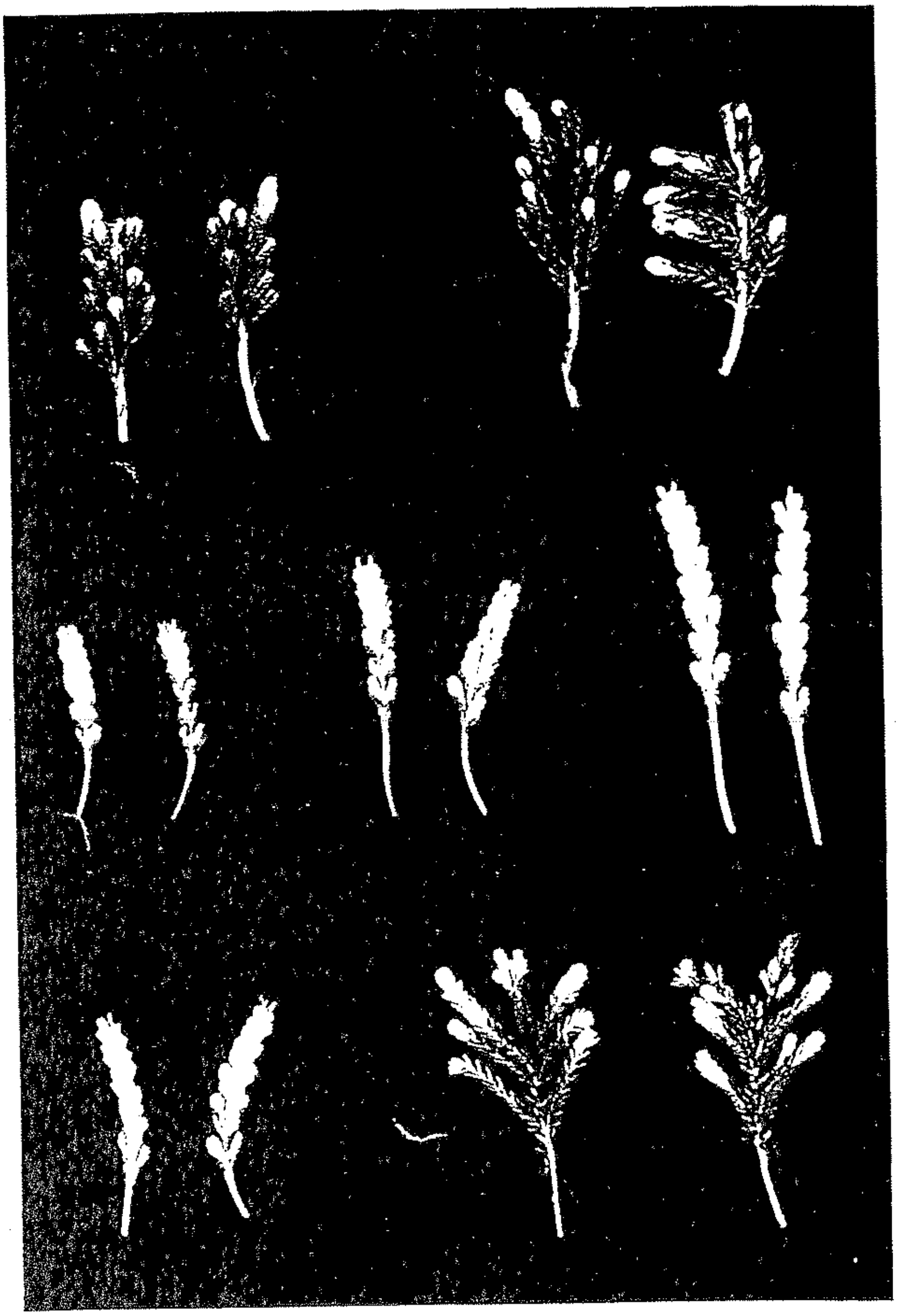
Bases



Above: 16 hour photoperiod (standard)

22 hour photoperiod (standard)

Plate 2: *Calluna vulgaris* 'Spring Glow'
Cutting types taken from plants grown under different lighting regimes in February 1994

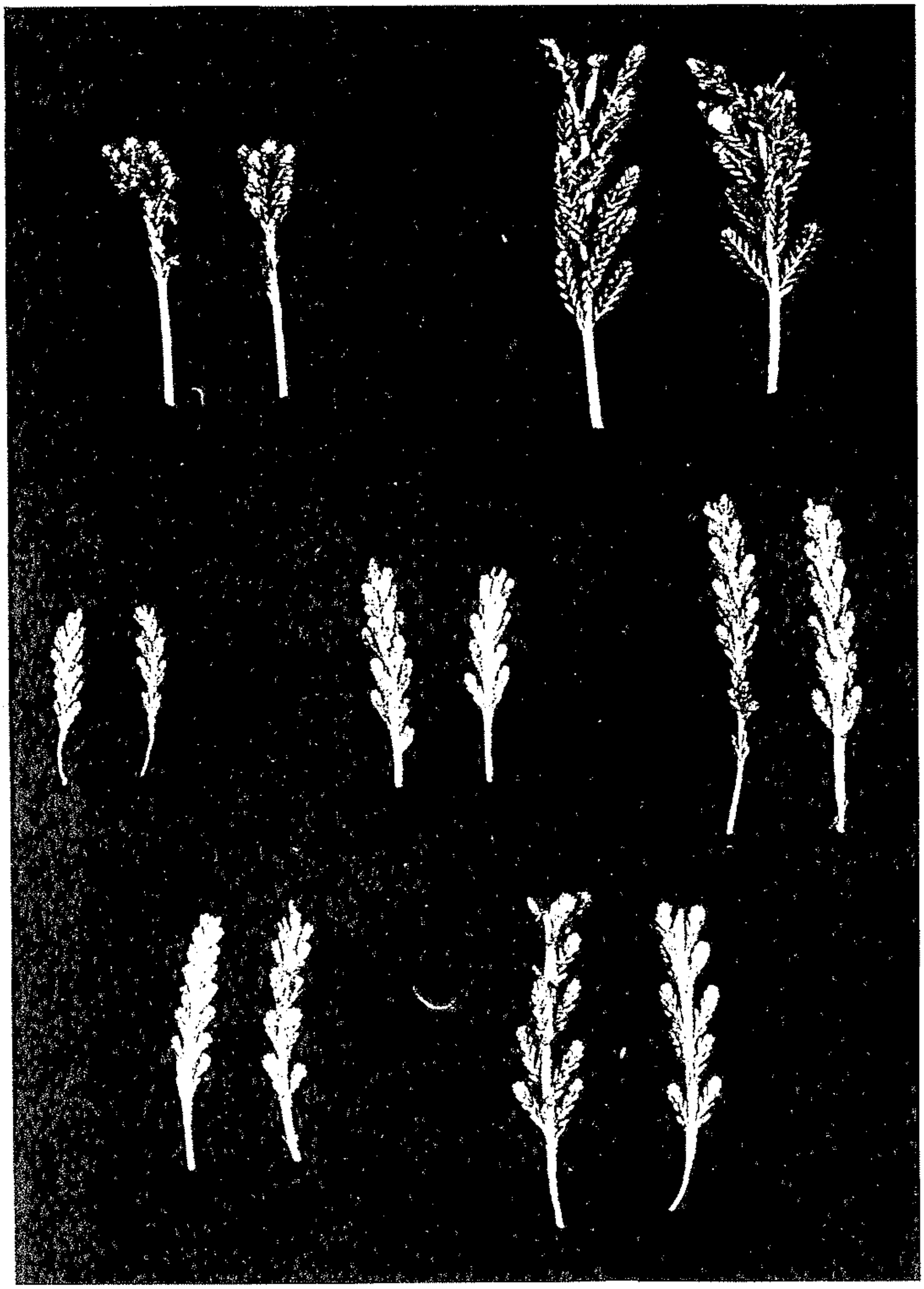


Natural daylight
LHS: tops
RHS: bases

16 hour photoperiod
From left to right:
small, medium, large

22 hour photoperiod
LHS: tops
RHS: bases

Plate 3: *Calluna vulgaris* 'H E Beale'
Cutting types taken from plants grown under different lighting regimes in February 1994



Natural daylight
LHS: tops
RHS: bases

16 hour photoperiod
From left to right:
small, medium, large

22 hour photoperiod
LHS: tops
RHS: bases

b) *Clematis*

Clematis 'Ernest Markham'
Clematis 'Jackmanii Superba'
Clematis 'Miss Bateman'
Clematis 'Nelly Moser'
Clematis 'The President'

Propagation regime

Rooting media:	75% Bulrush peat, 25% Cambark Fine
Modular tray:	QP77
Hormone dip:	500 ppm Synergol (5 second 'quick dip')
Propagation environment:	mist minimum temperature in growing media = 15°C
Time of cutting strike:	when growth on stock plants reached top of 75 cm cane
Type of cutting taken:	single node cutting with one leaf removed and the other reduced to a single leaflet.
Care of rooted cuttings:	when the majority of cuttings had rooted, trays were removed from the propagation environment and 'hardened off' prior to potting on.

c) Rhododendrons (liners)

Rhododendron impeditum
Rhododendron pemakoense
Rhododendron racemosum
Rhododendron 'Blue Diamond'
Rhododendron 'Blue Star'
Rhododendron 'Curlew'
Rhododendron 'Snipe'
Rhododendron 'Snow Lady'

d) Alpines ('finished' plants)

Campanula 'White Clips'
Dianthus 'Joy'
Dianthus 'Whatfield Gem'

Growth regulation treatments

paclobutrazol applied as 'Bonzi' at i) 0.6 ml/litre
ii) 1.2 ml/litre

as a foliar spray, once (12 January) or twice (12 January, 4 February) during the growing period.

Plant material

a) Heathers: stock plants supplied in 3 litre pots by Kingfisher Nurseries.

b) *Clematis*: supplied as liners by Wyevale Nurseries, potted on into deep 3 litre pots on receipt and used as 'stock' plants.

c) *Rhododendron*: bought in as liners from Round Pond Nurseries Ltd.

d) *Campanula* and *Dianthus*: bought in from Lucksbridge Nurseries Ltd, in 7 cm pots.

Experimental design

Due to practical limitations it was not possible to replicate treatments. The number of plants of each cultivar per treatment are listed below:

Stock plants	a) Heathers	3 plants
	b) *Clematis*	6 plants
Liners/'finished' plants	a) *Rhododendron*	16 plants
	b) Alpines	20 plants

RESULTS

For ease of interpretation the results have been subdivided into 4 sections:

1) Heathers
2) *Clematis*
3) *Rhododendron*
4) *Campanula* and *Dianthus*

1. Heathers

The total number of cuttings taken/plant for each cultivar is shown in Table 2, and the % rooting/cutting survival from each strike date in Tables 3 and 4. Detailed results are presented under each species/cultivar group.

Table 2: Total number of cuttings/plant according to treatment

Species/cultivar	October strike	February strike	October strike plus February strike 16 hour photoperiod	22 hour photoperiod
	Natural daylight			
E. carnea 'Myretoun Ruby'	29	63	34	55
E. carnea 'Springwood Pink'	43	73	50	93
E.x darleyensis 'Jack H Brummage'	61	82	87	111
E.x darleyensis 'Ghost Hills'	61	113	72	96
C. vulgaris 'Blazeaway'	61	94	146	182
C. vulgaris 'Spring Glow'	61	111	174	234
C. vulgaris 'H E Beale'	61	87	146	130
C. vulgaris 'Kinlochruel'	61	65	126	191

October strike: 4/5/6 October, cuttings taken from plants prior to introduction to lighting treatments. Plants 'trimmed' to shape after cuttings removed.

February strike: 2/3 February, cuttings taken from *Calluna vulgaris* cultivars grown under lights, and from plants of these cultivars grown in natural daylight and *NOT* used for cuttings in October 1993.

21/22 February, cuttings taken from cultivars of *E. carnea* and *E.x darleyensis* grown under lights, and from plants grown in natural daylight and *NOT* used for cuttings in October 1993.

Table 3: Final percentage rooting of cuttings from October strike as influenced by different lighting treatments following propagation

Species/cultivar	Lighting treatments after rooting					
	Natural daylight		16 hour photoperiod		22 hour photoperiod	
	+ hormone	- hormone	+ hormone	- hormone	+ hormone	- hormone
E. carnea 'Myretoun Ruby'	52%	58%	62%	56%	49%	56%
E. carnea 'Springwood Pink'	83%	54%	80%	66%	89%	52%
E.x darleyensis 'Jack H Brummage'	81%	89%	77%	91%	98%	84%
E.x darleyensis 'Ghost Hills'	65%	69%	71%	79%	79%	74%
C. vulgaris 'Blazeaway'	97%	98%	99%	100%	93%	95%
C. vulgaris 'Spring Glow'	75%	84%	84%	76%	70%	77%
C. vulgaris 'H E Beale'	96%	92%	92%	86%	92%	97%
C. vulgaris 'Kinlochruel'	79%	75%	91%	75%	92%	69%

Table 4: Final percentage rooting of cuttings from February strike (stock plants grown under lighting treatments)

Species/cultivar	Stock plants grown under:					
	Natural daylight		16 hour photoperiod		22 hour photoperiod	
	+ hormone	- hormone	+ hormone	- hormone	+ hormone	- hormone
E. carnea 'Myretoun Ruby'	36%	21%	25%	25%	59%	31%
E. carnea 'Springwood Pink'	39%	53%	60%	90%	32%	45%
E.x darleyensis 'Jack H Brummage'	90%	83%	100%	95%	97%	97%
E.x darleyensis 'Ghost Hills'	83%	76%	94%	87%	73%	65%
C. vulgaris 'Blazeaway'	93%	94%	96%	100%	92%	92%
C. vulgaris 'Spring Glow'	93%	95%	0%	0%	40%	42%
C. vulgaris 'H E Beale'	82%	87%	91%	78%	55%	60%
C. vulgaris 'Kinlochruel'	86%	88%	58%	53%	52%	68%

Erica carnea **'Myretoun Ruby' and 'Springwood Pink'**

At the beginning of the trial, stock plants of these two cultivars were smaller than those of the other two species groups, reflecting their natural growth habits/vigour. Consequently fewer cuttings were taken, particularly from **'Myretoun Ruby'** (Table 2, page 16).

By early February, plants of both cultivars grown in natural daylight (but not used for cuttings in October) had increased in size and yielded approximately twice the number of cuttings compared with the October strike (Table 2, page 16).

Growing plants of both of these cultivars in a 16 hour photoperiod from November - early February did little to improve growth and therefore increase the number of cuttings produced (Table 2, page 16). Plants of **'Myretoun Ruby'** grown in a 22 hour photoperiod yielded more cuttings, but still not as many as those available from plants left in natural daylight until early February before cuttings were taken. A small benefit in terms of increased cutting number was achieved with **'Springwood Pink'** in the longer photoperiod.

The % rooting/survival of **'Myretoun Ruby'** cuttings taken in October was disappointing, and was not improved by the use of a hormone dip (Table 4, page 17). In contrast, the rooting of cuttings of **'Springwood Pink'** was greatly improved where the hormone dip was used. Lighting treatment after rooting had little effect on % cutting survival, but improved growth particularly in the 22 hour photoperiod.

The % rooting/survival of cuttings taken in early February was even lower for both cultivars. The benefit of using a hormone dip at striking was no longer obvious with cuttings of **'Springwood Pink'**, and indeed appeared to be detrimental at the later strike date. Cuttings of both cultivars taken from the slightly 'harder' wood at the 'base' of shoots rooted better than those derived from the soft 'tops'. (Tables 5 and 6, page 19).

Table 5: Final percentage rooting of different cutting types of *E. carnea* 'Myretoun Ruby' struck in February 1994

Lighting treatment		Cutting type 'Tops'	 'Bases'	 'Tops only'
Natural daylight	+ hormone	29%	43%	NA
	– hormone	12%	30%	NA
16 hour photoperiod	+ hormone	NA	NA	25%
	– hormone	NA	NA	25%
22 hour photoperiod	+ hormone	NA	NA	59%
	– hormone	NA	NA	31%

NA: Not applicable

Table 6: Final percentage rooting of different cutting types of *E. carnea* 'Springwood Pink' struck in February 1994

Lighting treatment		Cutting type (see Plate 1, page 11) 'Tops'	 'Bases'	 'Tops only'
Natural daylight	+ hormone	33%	46%	NA
	– hormone	41%	65%	NA
16 hour photoperiod	+ hormone	NA	NA	60%
	– hormone	NA	NA	90%
22 hour photoperiod	+ hormone	NA	NA	32%
	– hormone	NA	NA	45%

NA: Not applicable

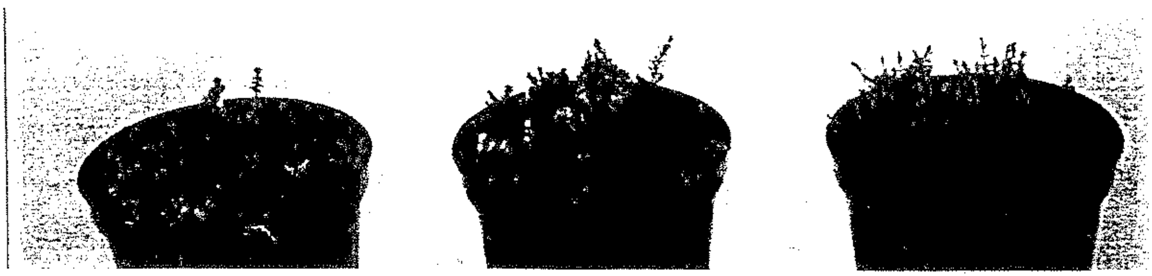
Plate 4: *Erica carnea* 'Myretoun Ruby' *(photographs taken late January 1994)*

Above: Plants grown in natural daylight
LHS: No cuttings taken in October 1993, showing material available for cuttings in February 1994
RHS: Regrowth after cuttings taken in October 1993

Above: Regrowth after cuttings taken in October 1993
Natural daylight | 16 hour photoperiod | 22 hour photoperiod

Plate 5: *Erica carnea* 'Springwood Pink' *(photographs taken late January 1994)*

Above: Plants grown in natural daylight
LHS: No cuttings taken in October 1993 showing material available for cuttings in February 1994
RHS: Regrowth after cuttings taken in October 1993



Above: Regrowth after cuttings taken in October 1993
Natural daylight | 16 hour photoperiod | 22 hour photoperiod

Erica x darleyensis **'Jack H Brummage' and 'Ghost Hills'**

At the beginning of the trial, stock plants of these two cultivars yielded a similar number of cuttings to those in the *Calluna vulgaris* group. (Table 2, page 16).

By early February the number of cuttings available from plants of both cultivars grown in natural daylight (and not used as a cutting source in October) had increased by 34% and 85% for **'Jack H Brummage'** and **'Ghost Hills'** respectively.

The additional growth achieved by growing stock plants in a 16 hour photoperiod after an initial harvest of cuttings in October provided few additional cuttings of either cultivar. However, a substantially greater number of cuttings were available from plants grown in a 22 hour photoperiod, particularly those of **'Jack H Brummage'**.

The % rooting/survival of cuttings taken in the October strike and grown on after rooting in the various lighting treatments was higher for **'Jack H Brummage'** than from **'Ghost Hills'**. The application of a hormone dip at striking did not markedly affect rooting/cutting survival. Growth was more advanced on rooted cuttings grown in the extended photoperiods, particularly the 22 hour photoperiod.

The % rooting/survival of cuttings taken in early February was slightly higher in most treatments than from the October strike, with virtually all the cuttings of **'Jack H Brummage'** taken from stock plants grown under lights surviving. A slight improvement in rooting was seen from cuttings of **'Ghost Hills'** given a hormone dip at striking.

The softer tips of **'Jack H Brummage'** rooted slightly better than 'base' cuttings. There was little consistent effect of cutting type on % rooting of **'Ghost Hills'**.

Table 7: Final percentage rooting of different cutting types of *E.x darleyensis* 'Jack H Brummage' struck in February 1994

Lighting treatment		Cutting type		
		'Tops'	'Bases'	'Tops only'
Natural daylight	+ hormone	92%	80%	NA
	– hormone	86%	70%	NA
16 hour photoperiod	+ hormone	NA	NA	100%
	– hormone	NA	NA	95%
22 hour photoperiod	+ hormone	NA	NA	97%
	– hormone	NA	NA	97%

NA: Not applicable

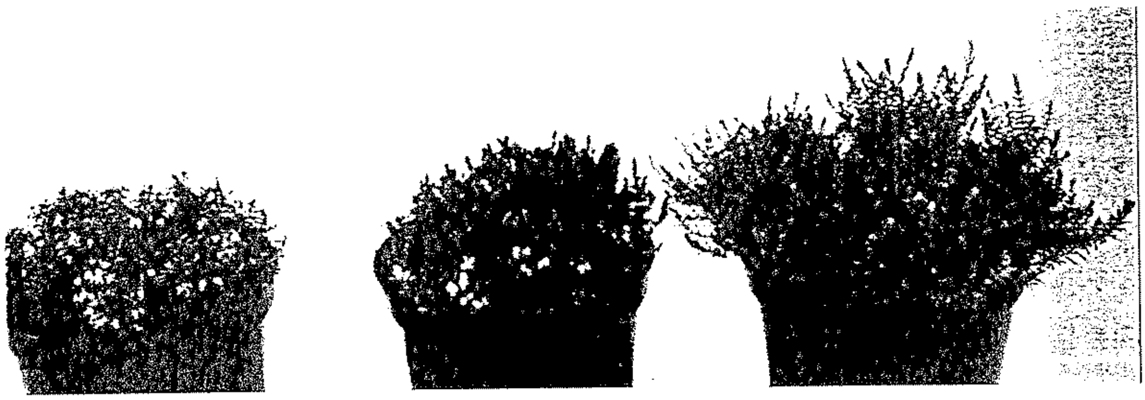
Table 8: Final percentage rooting of different cutting types of *E.x darleyensis* 'Ghost Hills' struck in February 1994

Lighting treatment		Cutting type		
		'Tops'	'Bases'	'Tops only'
Natural daylight	+ hormone	88%	74%	NA
	– hormone	69%	86%	NA
16 hour photoperiod	+ hormone	NA	NA	94%
	– hormone	NA	NA	87%
22 hour photoperiod	+ hormone	NA	NA	73%
	– hormone	NA	NA	65%

NA: Not applicable

Plate 6: *Erica x darleyensis* 'Jack H Brummage'

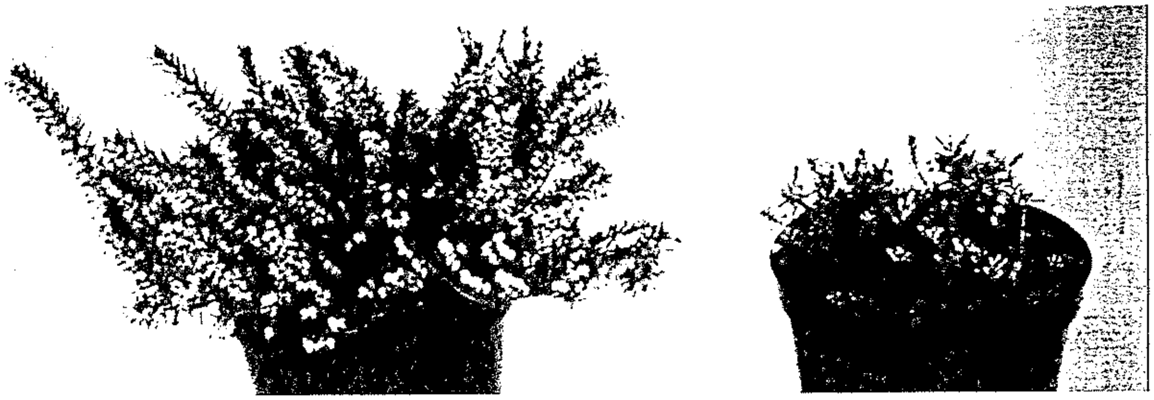
Above: Plants grown in natural daylight *(photograph taken late January 1994)*
LHS: No cuttings taken in October 1993, showing material available for cuttings in February 1994
RHS: Regrowth after cuttings taken in October 1993.



Above: Regrowth after cuttings taken in October 1993 *(photograph taken late January 1994)*
Natural daylight 16 hour photoperiod 22 hour photoperiod

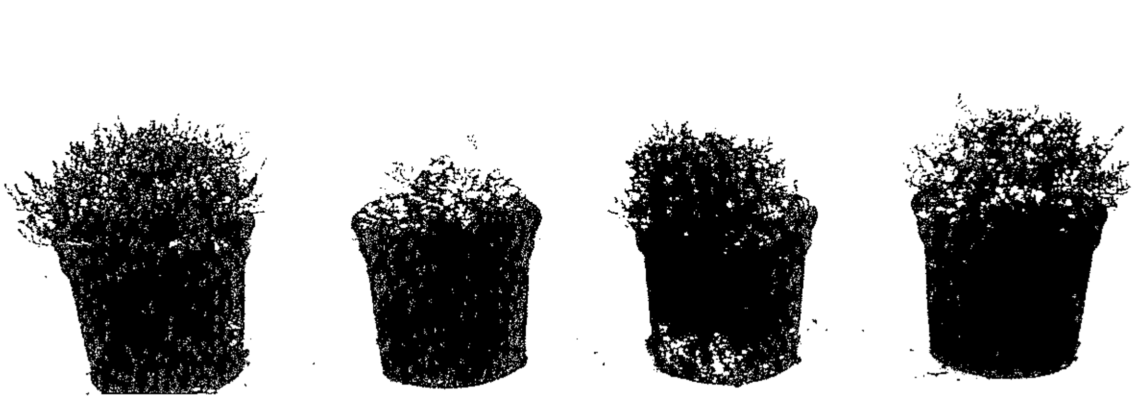
Above: Stock plants in late April 1994
Natural daylight October 1993 strike; Natural daylight February 1994 strike; 16 hour photoperiod; 22 hour photoperiod (October 1993 & February 1994 strike)

Plate 7: *Erica x darleyensis* 'Ghost Hills'



Above: Plants grown in natural daylight *(photograph taken late January 1994)*
LHS: No cuttings taken in October 1993, showing material available for cuttings in February 1994
RHS: Regrowth after cuttings taken in October 1993.

Above: Regrowth after cuttings taken in October 1993 *(photograph taken late January 1994)*
Natural daylight — 16 hour photoperiod — 22 hour photoperiod



Above: Stock plants in late April 1994
Natural daylight October 1993 strike — Natural daylight February 1994 strike — 16 hour photoperiod — 22 hour photoperiod (October 1993 & February 1994 strike)

Calluna vulgaris **'Blazeaway' and 'Spring Glow'** (gold foliage cultivars)

A similar number of cuttings was taken from plants of both of these cultivars at the beginning of the trial.

By early February 1994 a substantially greater number of cuttings was available from stock plants left unpruned in October and grown in natural daylight, than was taken at the earlier strike in October 1993, particularly from **'Spring Glow'** (Table 2, page 16).

Growing 'pruned' plants on under extended photoperiods greatly increased the yield of cuttings, particularly when a 22 hour photoperiod was used, and especially for **'Spring Glow'** (however, see comments on % survival, below).

Both the October and February strike of cuttings of **'Blazeaway'** rooted well. However, fewer cuttings (70-84%) of **'Spring Glow'** rooted from the October strike, with a hormone dip giving little consistent improvement.

The survival/rooting of cuttings taken in February from plants of **'Spring Glow'** grown under lights was exceptionally poor. The young growth was highly coloured (Plate 9, page 28) and soft, and proved unsuitable as a source of cuttings. This was highlighted by the results achieved with the 'top' and 'base' cuttings taken from plants grown in the 22 hour photoperiod: none of the 'tops' survived, whilst the 'harder' bases rooted and established well (Table 10, page 26).

The growth of rooted cuttings of both cultivars was markedly more advanced in the 16 hour and 22 hour photoperiods compared to those grown in natural daylight (Plate 8, page 27).

Table 9: Final percentage rooting of different cutting types of *C. vulgaris* 'Blazeaway' struck in February 1994

Lighting treatment		Cutting type				
		'Tops'	'Bases'	'Large'	'Medium'	'Small'
Natural daylight	+ hormone	96%	99%	NA	NA	NA
	– hormone	84%	81%	NA	NA	NA
16 hour photoperiod	+ hormone	NA	NA	100%	98%	93%
	– hormone	NA	NA	100%	100%	100%
22 hour photoperiod	+ hormone	94%	85%	NA	NA	NA
	– hormone	93%	90%	NA	NA	NA

NA: Not applicable

Table 10: Final percentage rooting of different cutting types of *C. vulgaris* 'Spring Glow' struck in February 1994

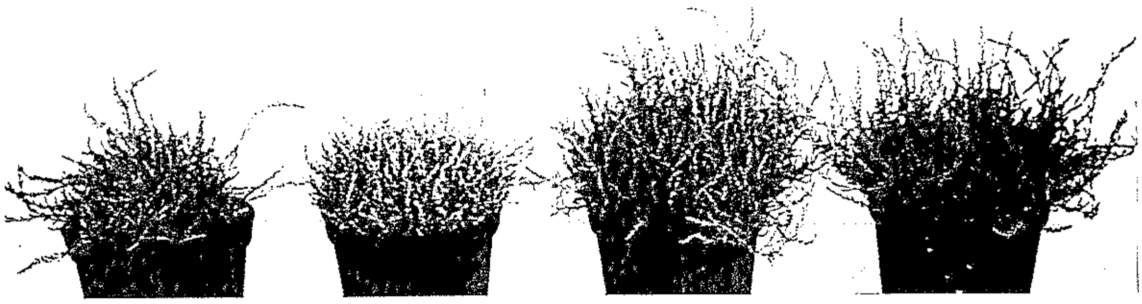
Lighting treatment		Cutting type (see Plate 2, page 00)				
		'Tops'	'Bases'	'Large'	'Medium'	'Small'
Natural daylight	+ hormone	92%	100%	NA	NA	NA
	– hormone	98%	80%	NA	NA	NA
16 hour photoperiod	+ hormone	NA	NA	0%	0%	0%
	– hormone	NA	NA	0%	0%	0%
22 hour photoperiod	+ hormone	4%	89%	NA	NA	NA
	– hormone	4%	93%	NA	NA	NA

NA: Not applicable

Plate 8: *Calluna vulgaris* 'Blazeaway'

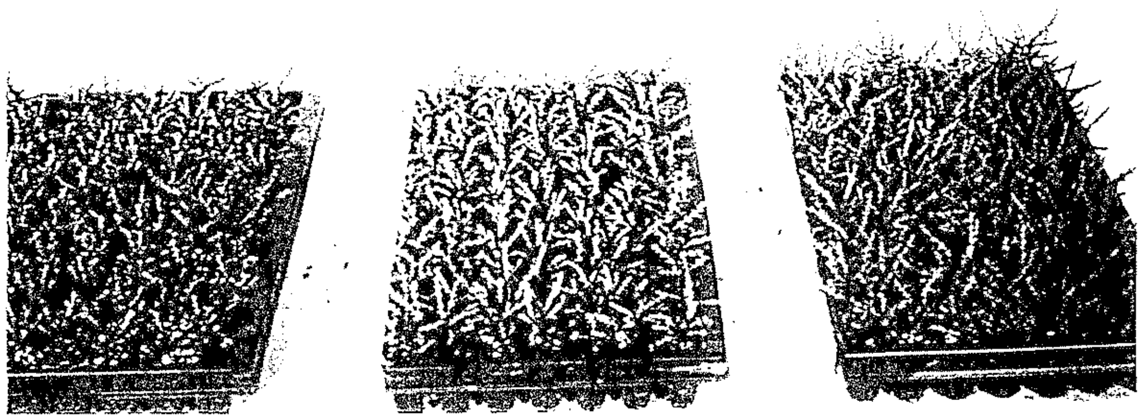
Above: Regrowth after cuttings taken in October 1993 *(photograph taken late January 1994)*

Natural daylight | 16 hour photoperiod | 22 hour photoperiod



Above: Stock plants in late April 1994

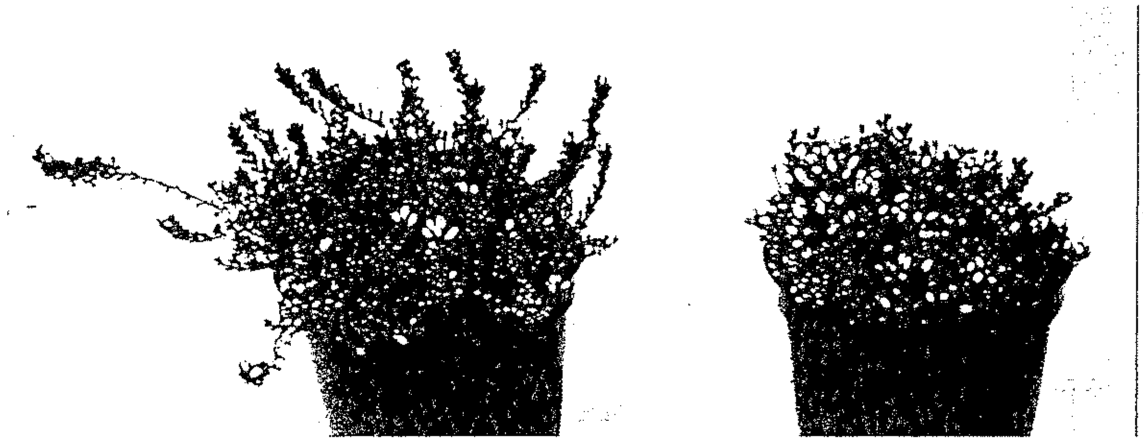
Natural daylight October 1993 strike | Natural daylight February 1994 strike | 16 hour photoperiod | 22 hour photoperiod (October 1993 & February 1994 strike)



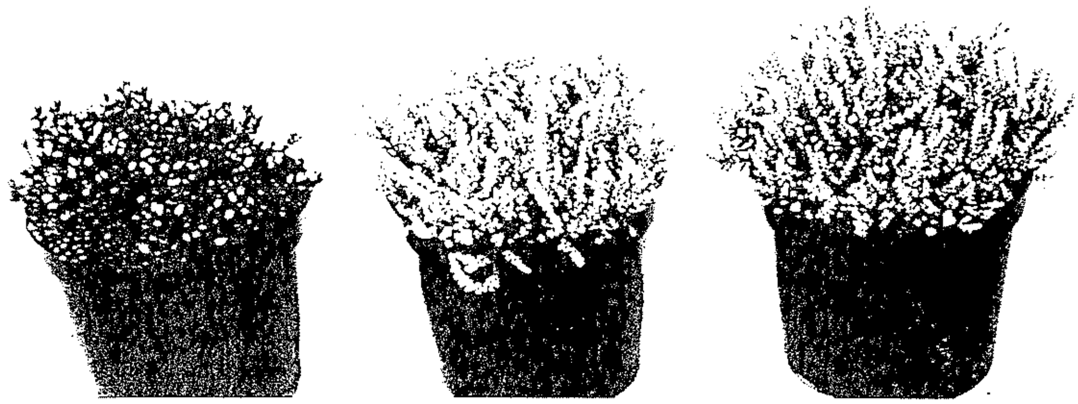
Above: Cuttings struck in October 1993 and grown in different lighting regimes *(photograph taken late April 1994)*

Natural daylight | 16 hour photoperiod | 22 hour photoperiod

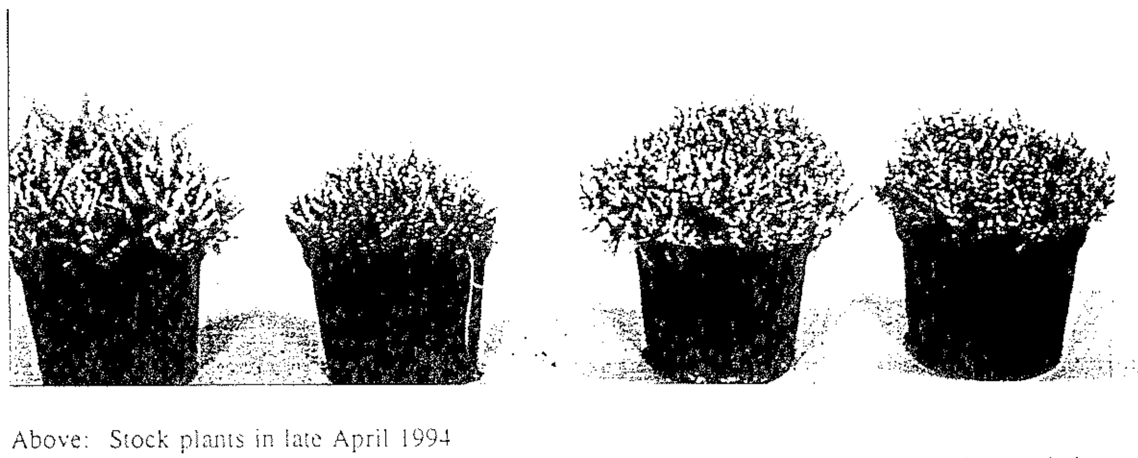
Plate 9: *Calluna vulgaris* 'Spring Glow'



Above: Plants grown in natural daylight *(photograph taken late January 1994)*
LHS: No cuttings taken in October 1993, showing material available for cuttings in February 1994
RHS: Regrowth after cuttings taken in October 1993.



Above: Regrowth after cuttings taken in October 1993 *(photograph taken late January 1994)*
Natural daylight | 16 hour photoperiod | 22 hour photoperiod



Above: Stock plants in late April 1994
Natural daylight October 1993 strike | Natural daylight February 1994 strike | 16 hour photoperiod | 22 hour photoperiod (October 1993 & February 1994 strike)

Note 'scorch' on tips of young growth on plants grown under lights

Calluna vulgaris **'H E Beale' and 'Kinlochruel'**

At the beginning of the trial a similar number of cuttings was taken from these 2 cultivars as from the gold foliage cultivars detailed previously.

The increase in cutting numbers on the plants grown in natural daylight (and not pruned in October) was not of the same magnitude as that seen with the gold foliaged cultivars. However, cutting yield was improved by growing plants in extended photoperiods, particularly from **'Kinlochruel'** grown in the 22 hour photoperiod.

The rooting/survival of cuttings of **'H E Beale'** taken in October was very good, with little benefit achieved from a hormone dip. A high % of **'Kinlochruel'** cuttings rooted, especially when a hormone dip was used prior to striking.

Rooted cuttings of both cultivars grown in 16 and particularly 22 hour photoperiods had made significantly more growth than those in natural daylight by the end of the trial (Plate 11, page 32).

Cuttings of **'H E Beale'** taken in February did not generally root as well as those taken earlier, although there was little correlation between cutting type and % rooting. The 'harder' cuttings taken from unpruned plants of **'Kinlochruel'** grown in natural daylight rooted more successfully than those taken from plants grown under lights, irrespective of photoperiod. The use of a hormone dip had no consistent effect on rooting at this strike.

Flowering on the stock plants of these two cultivars grown in the extended photoperiods was advanced compared to those plants grown in natural daylight (Plate 11, page 32 and Plate 12, page 33).

Table 11: Final percentage rooting of different cutting types of *C. vulgaris* 'H E Beale' struck in February 1994

Lighting treatment		Cutting type (see Plate 3, page 00) 'Tops'	'Bases'	'Large'	'Medium'	'Small'
Natural daylight	+ hormone	78%	86%	NA	NA	NA
	- hormone	86%	88%	NA	NA	NA
16 hour photoperiod	+ hormone	NA	NA	79%	100%	91%
	- hormone	NA	NA	74%	75%	80%
22 hour photoperiod	+ hormone	59%	42%	NA	NA	NA
	- hormone	61%	54%	NA	NA	NA

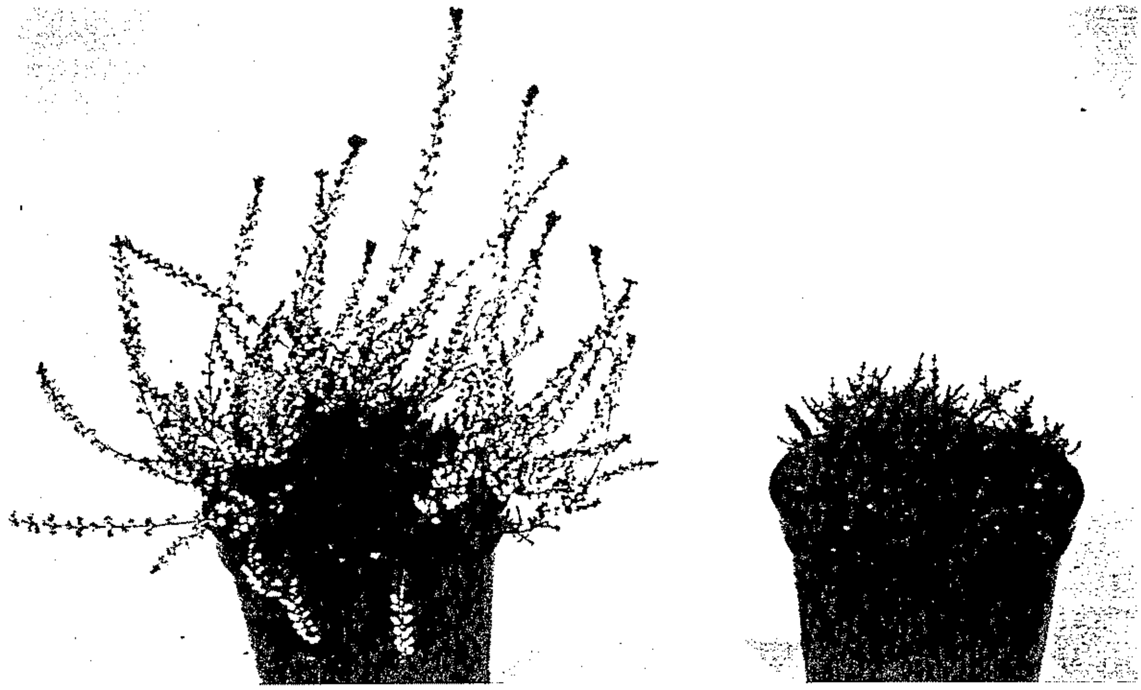
NA: Not applicable

Table 12: Final percentage rooting of different cutting types of *C. vulgaris* 'Kinlochruel' struck in February 1994

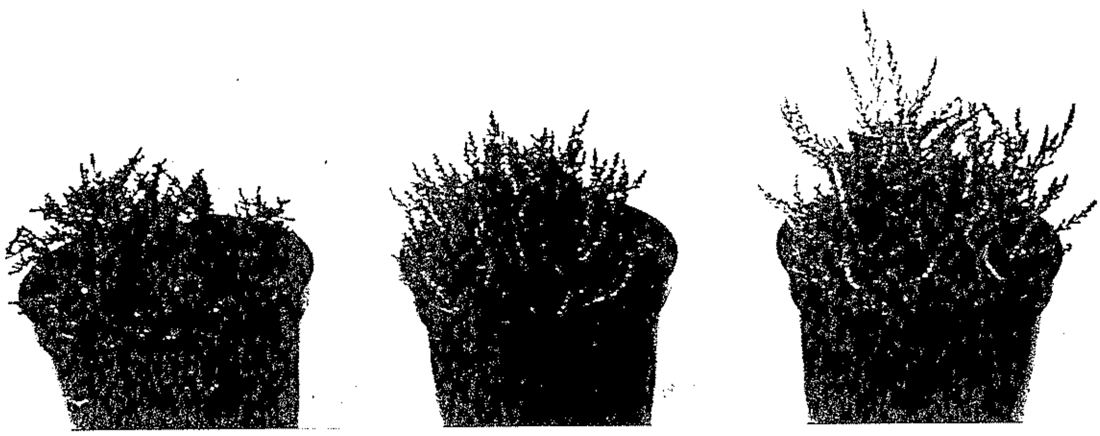
Lighting treatment		Cutting type 'Tops'	'Bases'	'Large'	'Medium'	'Small'
Natural daylight	+ hormone	84%	92%	NA	NA	NA
	- hormone	90%	69%	NA	NA	NA
16 hour photoperiod	+ hormone	NA	NA	69%	43%	63%
	- hormone	NA	NA	63%	57%	48%
22 hour photoperiod	+ hormone	50%	55%	NA	NA	NA
	- hormone	65%	74%	NA	NA	NA

NA: Not applicable

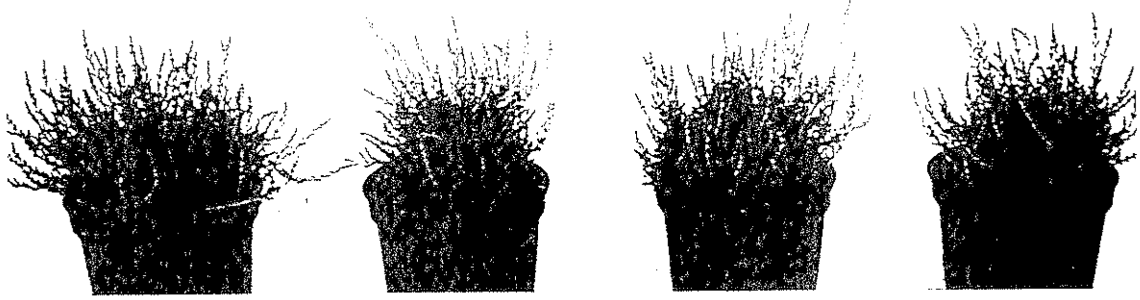
Plate 10: *Calluna vulgaris* 'H E Beale'



Above: Plants grown in natural daylight *(photograph taken late January 1994)*
LHS: No cuttings taken in October 1993, showing material available for cuttings in February 1994
RHS: Regrowth after cuttings taken in October 1993.

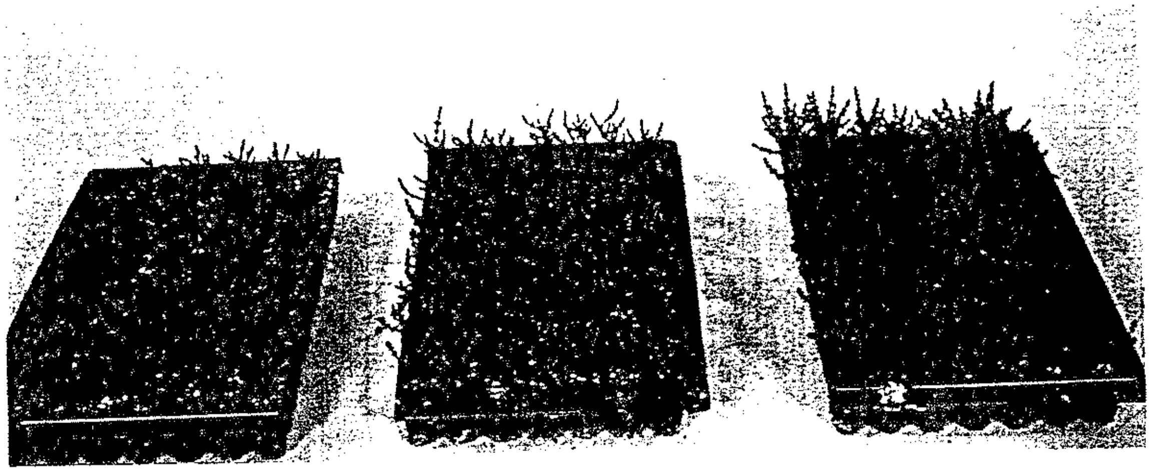


Above: Regrowth after cuttings taken in October 1993 *(photograph taken late January 1994)*
Natural daylight — 16 hour photoperiod — 22 hour photoperiod



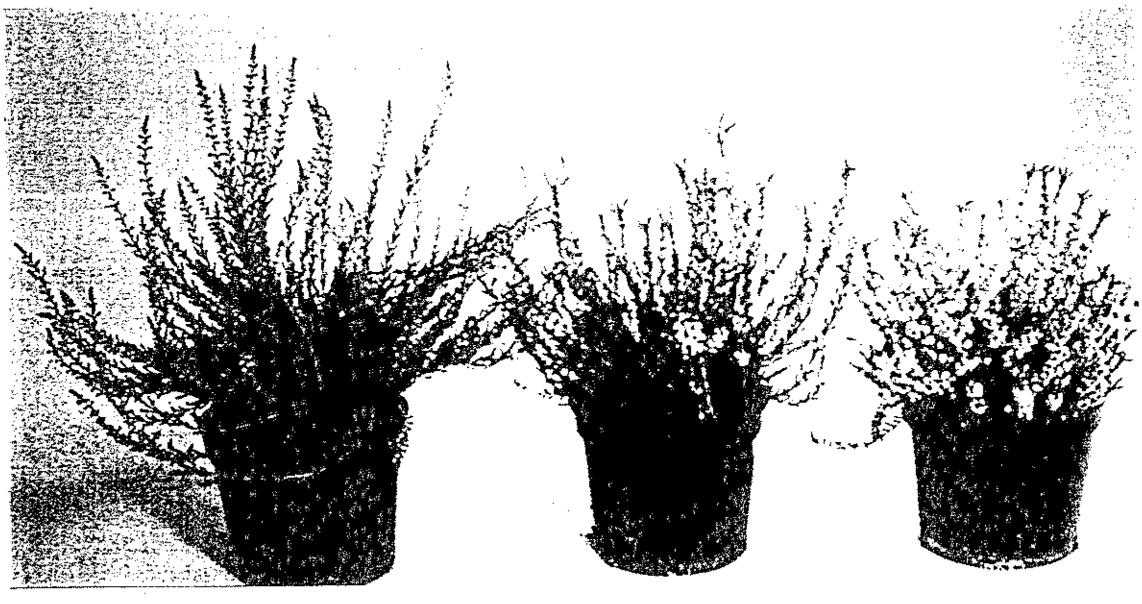
Above: Stock plants in late April 1994
Natural daylight, October 1993 strike — Natural daylight, February 1994 strike — 16 hour photoperiod — 22 hour photoperiod (October 1993 & February 1994 strike)

Plate 11: *Calluna vulgaris* 'H E Beale'



Above: Cuttings struck in October 1993 and grown in different lighting regimes (*photograph taken late April 1994*)

Natural daylight | 16 hour photoperiod | 22 hour photoperiod

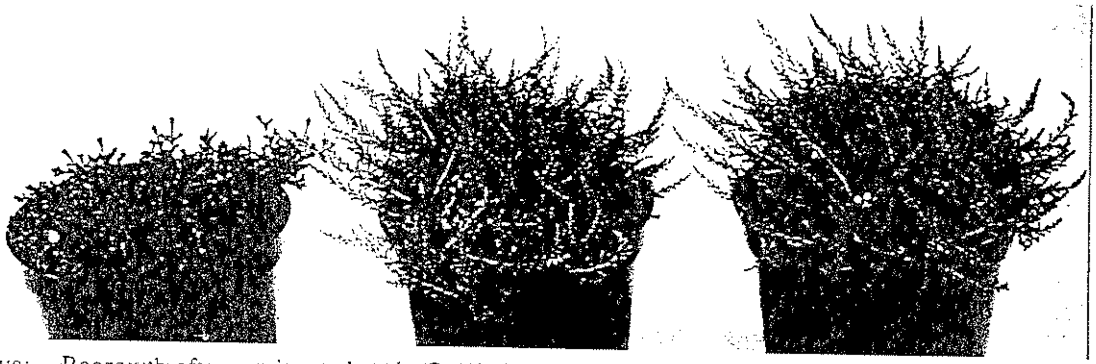


Above: Stock plants in late June 1994, showing influence of lighting regime (from October 1993 - end of March 1994) on flowering

Natural daylight | 16 hour photoperiod | 22 hour photoperiod

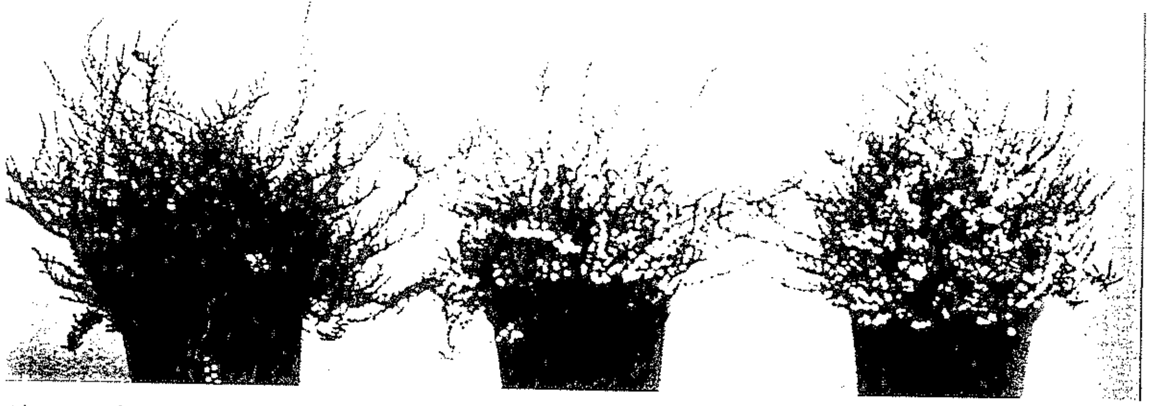
Plate 12: *Calluna vulgaris* 'Kinlochruel'

Above: Plants grown in natural daylight *(photograph taken late January 1994)*
LHS: No cuttings taken in October 1993, showing material available for cuttings in February 1994
RHS: Regrowth after cuttings taken in October 1993.



Above: Regrowth after cuttings taken in October 1993 *(photograph taken late January 1994)*
Natural daylight — 16 hour photoperiod — 22 hour photoperiod

Above: Stock plants in late April 1994
Natural daylight October 1993 strike — Natural daylight February 1994 strike — 16 hour photoperiod — 22 hour photoperiod (October 1993 & February 1994 strike)



Above: Stock plants in late June 1994, showing influence of lighting regime (from October 1993 - end of March 1994) on flowering
Natural daylight — 16 hour photoperiod — 22 hour photoperiod

After the lighting treatments finished at the end of March, the stock plants were grown on in natural daylight. In June 1994 the number of cuttings available was recorded, to determine the 'residual' effects of lighting treatment on growth (see Table 13 below).

Table 13: Number of cuttings available/plant in June 1994

Species/cultivar	Natural daylight October strike	Natural daylight February strike	16 hour photoperiod	22 hour photoperiod
E. carnea 'Myretoun Ruby'	70	57	90	97
E. carnea 'Springwood Pink'	97	67	70	100
E.x darleyensis 'Jack H Brummage'	173	104	240	157
E.x darleyensis 'Ghost Hills'	120	53	133	77
C. vulgaris 'Blazeaway'	142	117	201	120
C. vulgaris 'Spring Glow'	27	70	0 *	0 *
C. vulgaris 'H E Beale'	100	72	173	106
C. vulgaris 'Kinlochruel'	108	82	113	167

* No cuttings available due to 'scorch' at tips of young growth

2. Clematis

The effect of lighting regime on stock plant growth varied with cultivars. Early growth was stimulated on plants of **'Ernest Markham'** (see Plate 13, page 39) and **'Jackmanii Superba'**, grown in extended photoperiods particularly the 22 hour photoperiod. The first batch of cuttings was taken from 'lit' plants of both of these cultivars a month earlier than those grown in natural daylight.

The total number of cuttings produced by plants of **'Ernest Markham'** grown in a 22 hour photoperiod was three times greater than those grown in natural daylight. The magnitude of increase in cutting number was not so great with **'Jackmanii Superba'**, but the trend was similar (Table 14, page 36).

Although plants of **'Miss Bateman'** grown in extended photoperiods yielded almost twice as many cuttings as those grown in natural daylight, the time of cutting strike was not advanced.

Similar numbers of cuttings were taken from plants of **'Nelly Moser'** and **'The President'**, but the first strike was made almost a month earlier from plants grown in the longer photoperiods.

The speed of rooting and % cutting survival also varied with cultivar. Cuttings of **'Ernest Markham'** rooted quickly, with the majority of those from the early February and early March strikes rooting sufficiently well by late May to be potted. Although most of the cuttings from the late March strike developed roots only two thirds rooted sufficiently well to be potted.

Rooting was slower with the remaining cultivars. Few of the cuttings of **'Jackmanii Superba'** struck in early February had rooted by the end of May and none well enough to be potted. Similarly slow rooting was evident with the later strikes, particularly on cuttings from plants grown in the extended photoperiods (this trend was also noted with **'The President'**).

Rooting was also slow with **'Miss Bateman'**, and many of the cuttings from the late March strike had died by the end of May.

Table 14: Mean number of cuttings/plant according to strike date

Cultivar	Strike date (1994)	Natural daylight	16 hour photoperiod	22 hour photoperiod
'Ernest Markham'	2 Feb	0	5.0	9.3
	4 March	3.0	0	1.0
	31 March	2.2	9.2	5.5
Total		*5.2*	*14.2*	*15.8*
'Jackmanii Superba'	2 Feb	0	1.3	4.4
	4 March	1.2	2.3	0.3
	31 March	4.0	4.0	5.0
Total		*5.2*	*7.6*	*9.7*
'Miss Bateman'	2 Feb	0	0	0
	4 March	0	1.3	0
	31 March	4.9	7.3	8.0
Total		*4.9*	*8.6*	*8.0*
'Nelly Moser'	2 Feb	0	0	0
	4 March	0	0	6.3
	31 March	8.5	7.0	1.7
Total		*8.5*	*7.0*	*8.0*
'The President'	2 Feb	0	0	0
	4 March	0	2.3	3.2
	31 March	6.9	2.6	2.6
Total		*6.9*	*4.9*	*5.8*

Table 15: Summary of root development on cuttings according to strike date

Cultivar	Strike date (1994)	Dead	Alive (no callus/roots)	Callus only	Rooting Category 1	2	3	4	5
'Ernest Markham'									
16 hour	2 Feb	0	0	0	0	0	13	9	8
22 hour	2 Feb	1	0	0	4	1	27	17	6
Nat day	4 March	0	0	0	0	0	12	9	3
22 hour	4 March	0	0	0	0	0	3	2	1
Nat day	31 March	1	0	2	0	3	6	6	0
16 hour	31 March	0	2	0	5	5	8	35	0
22 hour	31 March	0	0	0	6	7	9	11	0
'Jackmanii Superba'									
16 hour	2 Feb	0	1	0	7	0	0	0	0
22 hour	2 Feb	5	0	0	11	10	0	0	0
Nat day	4 March	0	0	1	4	2	3	0	0
16 hour	4 March	0	1	1	1	7	4	0	0
22 hour	4 March	0	0	0	0	0	2	0	0
Nat day	31 March	0	0	0	4	13	12	3	0
16 hour	31 March	0	2	3	6	12	1	0	0
22 hour	31 March	8	2	3	4	10	3	0	0
'Miss Bateman'									
16 hour	4 March	1	1	0	1	0	3	2	0
Nat day	31 March	7	0	10	12	4	4	2	0
16 hour	31 March	6	4	14	12	7	1	0	0
22 hour	31 March	8	7	19	4	6	4	0	0
'Nelly Moser'									
22 hour	4 March	0	0	24	6	0	8	0	0
Nat day	31 March	4	7	12	16	6	14	9	0
16 hour	31 March	0	2	14	12	5	9	0	0
22 hour	31 March	0	2	4	2	2	0	0	0
'The President'									
16 hour	4 March	0	0	0	0	0	8	5	0
22 hour	4 March	1	0	1	2	4	6	5	0
Nat day	31 March	0	1	0	12	18	24	0	0
16 hour	31 March	1	0	0	3	8	4	0	0
22 hour	31 March	0	0	1	6	9	0	0	0

Rooting Category
1. V. poorly rooted, only 2-3 roots, <3-4 cm long
2. Poorly rooted, roots visible on 1 side of plug only
3. Moderately well rooted, roots visible on > 1 side of plug
4. Well rooted, roots visible on all sides of plug, but < half way up
5. Very well rooted, roots visible on all sides of plug, > half way up

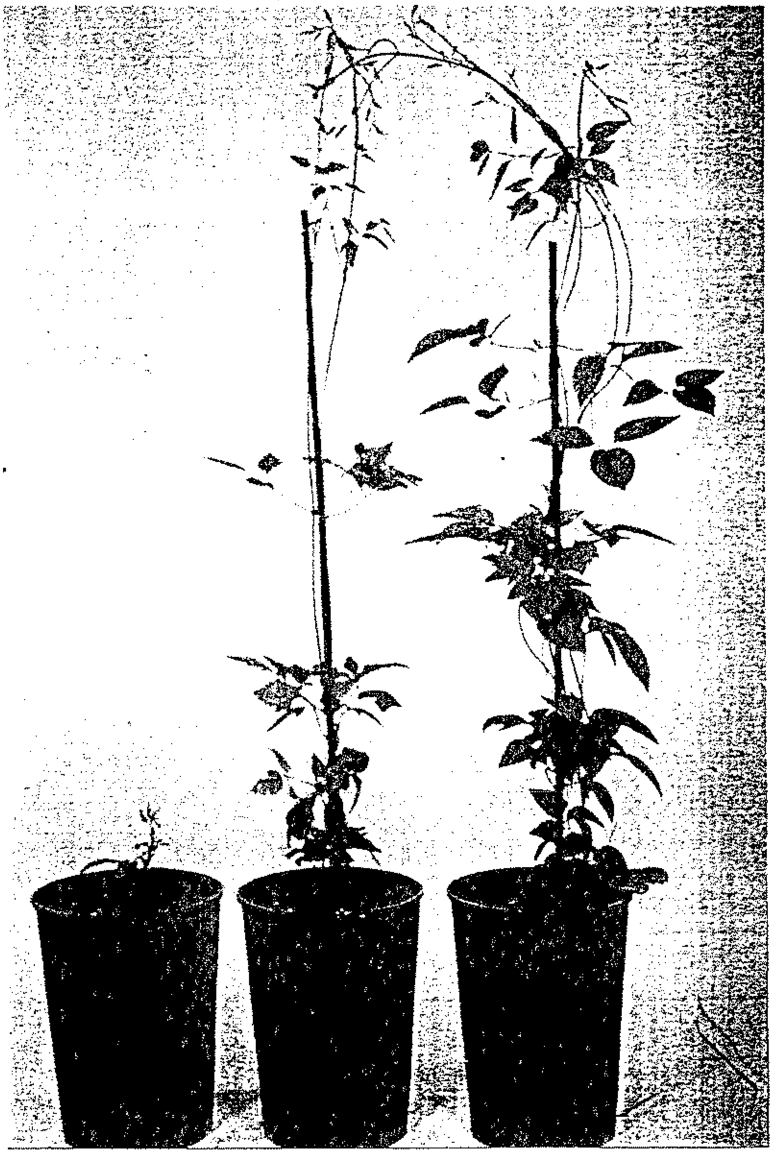
Categories 3-5 regarded as sufficiently well rooted to be potted on.

Table 16: Percentage cuttings rooted sufficiently to be potted on by 28 May 1994

Cultivar	Strike date (1994)	Natural daylight	16 hour photoperiod	22 hour photoperiod
'Ernest Markham'	2 Feb	NA	100%	89%
	4 March	100%	NA	100%
	31 March	67%	78%	61%
'Jackmanii Superba'	2 Feb	NA	0%	0%
	4 March	30%	29%	100%
	31 March	47%	4%	10%
'Miss Bateman'	4 March	NA	63%	NA
	31 March	15%	2%	8%
'Nelly Moser'	4 March	NA	NA	21%
	31 March	34%	21%	0%
'The President'	4 March	NA	100%	58%
	31 March	44%	25%	0%

NA: No cuttings taken from these treatments on these dates

Plate 13: *Clematis* 'Ernest Markham' (*photograph taken late January 1994*)



Above: Stock plants grown in different lighting regimes.
Left to right: Natural daylight; 16 hour photoperiod; 22 hour photoperiod

3. Rhododendrons

Budded liners of each cultivar were used. The response of the different cultivars to the different lighting regimes varied widely.

Rhododendron impeditum

Lighting treatment had little effect on growth or flowering period of plants of this cultivar.

Rhododendron pemakoense (Plate 14, page 42)

Although little new growth occurred on any of the plants, those grown in natural daylight flowered earlier than those in the extended photoperiods. By mid March plants in natural daylight were in full flower whilst those in the 22 hour photoperiod were only just beginning to show colour in the buds.

Rhododendron racemosum

Half of the plants of this cultivar were pruned back hard at the start of the trial, with the remainder left unpruned. By mid March new shoot growth (about 1-2 cm long) was present on all of the pruned plants, irrespective of lighting treatment. Flowering was not affected by treatment on plants which had not been pruned.

Rhododendron **'Blue Diamond'**

Half of the plants of this cultivar were cut back hard at the beginning of the trial. Regrowth on pruned plants grown in natural daylight started earlier than on those grown in either of the extended photoperiods. Flowering on unpruned plants was very variable, but did not appear to be affected by lighting treatment.

Rhododendron 'Blue Star'

New shoot growth on pruned plants grown in natural daylight started earlier than on plants grown in either of the extended photoperiod treatments. Young shoots 2-3 cm long were present on plants in natural daylight whilst those in the 22 hour photoperiod had not started to grow away by early March. Flower bud development was also slightly more advanced on plants in natural daylight with colour showing in buds on approximately 50% of plants in early March, whilst no colour at all was visible in buds on plants grown in the 22 hour photoperiod.

Rhododendron **'Curlew'**

Shoot growth was markedly advanced on plants grown in a 22 hour photoperiod compared to those in natural daylight. No new shoot growth was present on plants in natural daylight in early March whilst 4-5 cm long shoots were common on those grown in the 22 hour photoperiod. Photoperiod length did not affect flowering.

Rhododendron **'Snipe'**

Half of the plants of this cultivar were pruned back at the start of the trial, but the majority of these had died by early March regardless of treatment. Flowering was slightly earlier on plants grown in natural daylight with flower buds showing some colour by early March, whilst those grown in the extended photoperiods were still in tight bud.

Rhododendron **'Snow Lady'** (Plate 15, page 42)

Plants grown in natural daylight flowered much earlier than those under lights, but no new shoot growth had occurred on these plants by early March. Conversely plants grown in the 16 hour and particularly the 22 hour photoperiod produced vegetative shoots at the expense of flowers.

Plate 14: Rhododendron pemakoense (*photograph taken mid March 1994*)

Above: Effects of lighting on flowering period
Natural daylight 16 hour photoperiod 22 hour photoperiod

Plate 15: *Rhododendron* 'Snow Lady' (*photograph taken mid March 1994*)

Above: Effects of lighting on flowering period and growth
Natural daylight 16 hour photoperiod 22 hour photoperiod

4. *Campanula* and *Dianthus*

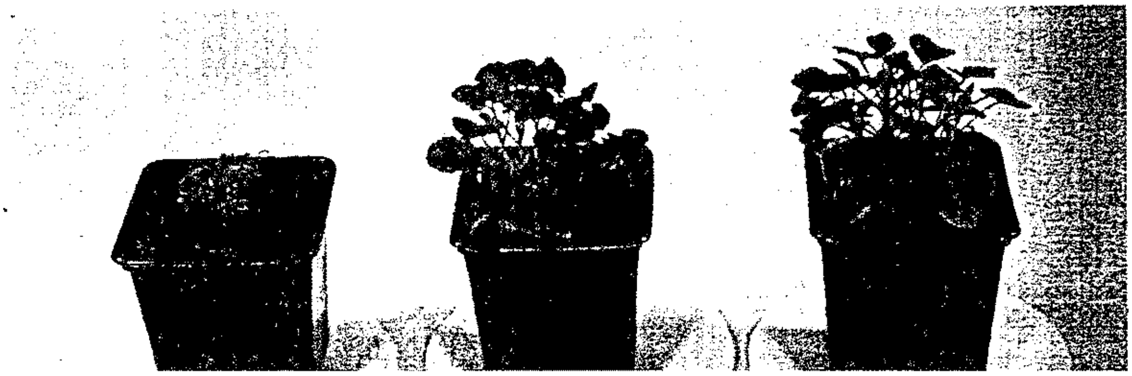
Growth and flowering on plants of *Campanula* **'White Clips'** were significantly advanced by the longer photoperiods. By mid April plants grown in the 22 hour photoperiod had started to flower, three to four weeks in advance of those grown in the 16 hour photoperiod and six to eight weeks earlier than those grown in natural daylight (Plate 16, page 44).

A single foliar spray of 'Bonzi' at 0.6 ml/litre or 1.2 ml/litre gave some control of growth but the best results were achieved when two sprays of 1.2 ml/litre were applied (Plate 17, page 45).

Flowering was advanced on both cultivars of ***Dianthus*** when plants were grown in the extended photoperiods, particularly the 22 hour photoperiod (Plate 17, page 45).

'Bonzi' sprays had little effect on the growth of either cultivar at the concentration used.

Plate 16: *Campanula* 'White Clips' Effect of lighting regime on growth and flowering
From left to right: Natural daylight; 16 hour photoperiod; 22 hour photoperiod



Above: Photograph taken late January 1994

Above: Photograph taken mid March 1994

Above Photograph taken late April 1994

Plate 17: *Campanula* 'White Clips'

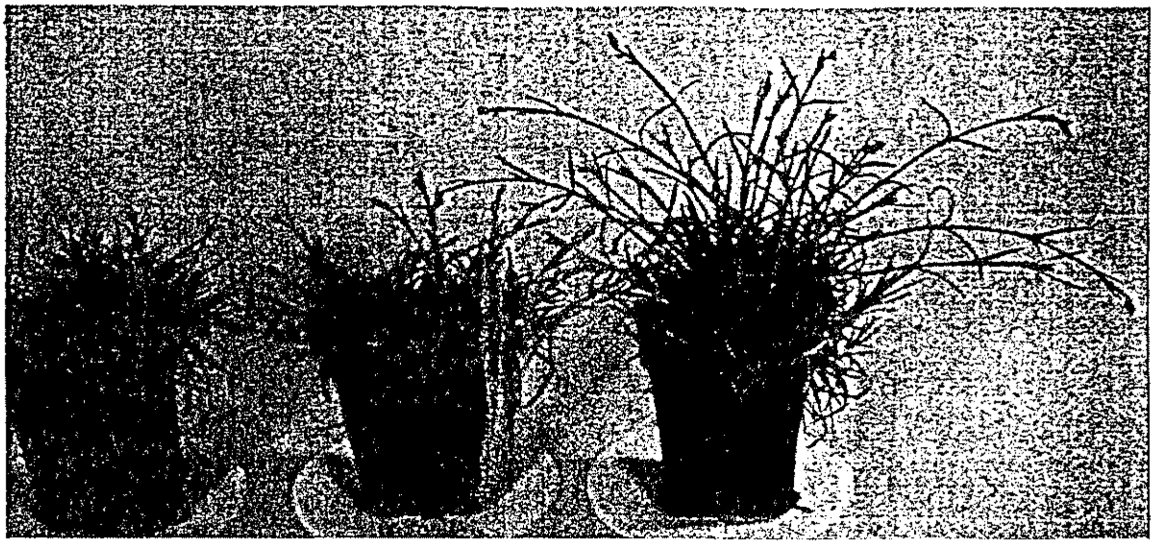
Above: Effect of treatment with 'Bonzi' on plants grown in 22 hour photoperiod (*photograph taken mid March 1994*)

Untreated control | 'Bonzi' at 1.2 ml/litre

Above: Effect of treatment with 'Bonzi' on plants grown in 22 hour photoperiod (*photograph taken early May 1994*)

Untreated control | 'Bonzi' at 0.6 ml/litre (2 sprays) | 'Bonzi' at 1.2 ml/litre (2 sprays)

Plate 18: *Dianthus* **'Whatfield Gem'** Effect of lighting regime on growth and flowering
From left to right: Natural daylight; 16 hour photoperiod; 22 hour photoperiod



Above: Photograph taken late January 1994

Above: Photograph taken mid March 1994

DISCUSSION

Supplementary lighting has been used for many years to programme the production of cut flowers and pot plants, but has only recently been considered in the UK for the manipulation of growth of nursery stock species.

Previous work has shown that for most subjects extension of photoperiod to 16 or preferably 22 hours/day over the winter period, using high pressure sodium lamps to supply a minimum light level of 2000 lux has the greatest effect on growth (and in the case of alpines, flowering). In addition a 'cool' air temperature regime has been shown to be essential to maintain quality and to avoid excessively soft growth with long internodes.

Since the provision of lighting requires an outlay of capital, this investment must be recouped either directly by an increased return for the product or indirectly by, for example, increased production or avoidance of labour peaks on the nursery.

The improved early growth achieved under lights is not only of benefit on plants for sale, but as shown in this year's work, also on stock plants, offering potential for bringing forward or extending the propagation season. However, in order to be cost effective the improved growth must be of sufficient magnitude to defray the costs across a large number of cuttings. For example, the relatively small increase in the number of cuttings produced on stock plants of *Erica carnea* **'Myretoun Ruby'** and **'Springwood Pink'** grown under lights is unlikely to cover the cost of lighting. In contrast, the technique may be viable for cultivars of *Calluna vulgaris* where the improvement in early growth (after an October strike) gave a significant second harvest of cuttings in February, in addition to the October strike. Plants grown in natural daylight did not produce sufficient regrowth to allow a second harvest this early. With such 'responsive' cultivars not only can the propagation season be extended but the number of cuttings produced/plant significantly increased.

However, the growth produced on plants under lights was relatively 'soft', and with some cultivars this growth would be unsuitable for use immediately as cuttings. This was evident when cuttings taken from the highly coloured very soft young growth on plants of *Calluna vulgaris* 'Spring Glow' grown under lights failed to root and subsequently died. This soft growth can also become 'scorched' under lights (even at the relatively low light level of 2000 lux), rendering it unsuitable for cuttings. More success may have been achieved if the stock plants had been removed from the lights for a few weeks to allow the growth to harden off before striking the cuttings. This needs further investigation.

Extrapolation of these results, allowing for plants to acclimatise following lighting, suggests that cuttings could be available some 6-8 weeks before those from plants grown in natural daylight.

This offers the opportunity to selectively light stock plants of a range of cultivars, to extend the propagation season and even out labour peaks.

The earlier growth on cuttings taken in October, and grown in extended photoperiods after rooting allows for handling several weeks earlier than those grown in natural daylight, extending the potting/sales season. In addition, labour peaks can be evened out by scheduling the production of batches of plants over a longer period, and/or increasing the number of plants produced.

The effect of a 'quick dip' in Synergol on rooting was inconsistent and varied with time of strike and cultivar/species, for example cuttings of **'Springwood Pink'** taken in October rooted more successfully after a 'quick dip', but the converse applied at the February strike. This may reflect the 'ripeness' of the cuttings on the two different dates, with the 'harder' cuttings taken in October benefiting from the stimulus of a rooting hormone to improve rooting success.

An additional potential advantage noted with *C. vulgaris* **'H E Beale'** and **'Kinlochruel'** was an advancement of flowering (by several weeks) on stock plants grown in the longer photoperiods after the early February strike. This offers the opportunity of providing flowering plants of these particularly attractive double flowered cultivars several weeks in advance of their natural flowering season - after sufficient 'hardening off'. By lighting several batches of stock plants in sequence, this flowering plant could be produced over a considerably extended period, resulting in an increased volume of sales.

With *Clematis* stock plants the variation in the commencement of growth of the different cultivars under lights may limit the viability of lighting for this group of plants to those cultivars which flush early and root readily, for example **'Ernest Markham'**.

The objective of using lighting to advance flowering on well established liners of *Rhododendron* already in bud was not met. With some cultivars, lighting promoted a flush of vegetative growth to the detriment of flowering, e.g. *R.* 'Snow Lady', whilst with others flowering was actually delayed, e.g. *R. pemakoense*.

The efficacy of 'Bonzi' applied to improve quality by reducing internode length and producing more compact plants varied. 'Bonzi' gave good growth control when applied to *Campanula*, producing compact, good quality plants. Further work is required to determine a rate suitable for *Dianthus*, and to evaluate other plant growth regulators.

The following costings have been provided by Chris Plackett of EA Technology Ltd, and were calculated on the basis of:

i) a lighting level of 2000 lux supplied by high pressure sodium lamps (each lamp covering an area of approximately 12.5m²)

ii) a cost of £180 per lamp and luminaire installed

iii) each lamp rated at 440 Watts

iv) an electricity cost of 8.5p/kWh peak, 2.8p/kWh off peak

Running costs (£/m²) as follows:

	Total lighting period	
Hours/day	100 days	150 days
16	3.36	5.12
22	5.04	7.68

Ownership costs £/m² p.a.

Depreciation period		
5 years	7 years	10 years
3.74	2.92	2.30

* Note, high pressure sodium lamps have on average a useful life in excess of 10,000 hours, with replacement lamps costing in the region of £35 each.

In the 'worst case' scenario, using a depreciation period of 5 years, and lighting for 100 days using a 22 hour photoperiod, the cost of lighting a pot thick population of 9 cm pots (i.e. 121 plants/m²) is approximately 7p/plant.

With some species such as *Campanula* this cost could be spread over two or three crops in a single season.

These costings may be useful as a guide to growers but each nursery will have its own specific requirements and costs may therefore vary accordingly.

CONCLUSIONS

Supplementary lighting, using high pressure sodium lamps to provide 16 or 22 hour photoperiods could have potential for:

Heather: stock plants

- Sufficient regrowth occurred on stock plants of 4 cultivars of *Calluna vulgaris* grown in 16 and 22 hour photoperiods from October onwards to allow a second harvest of cuttings in early February, after a previous strike in early October. Although cuttings from 3 of these 4 cultivars established successfully, those taken from the highly coloured young/soft growth of *C. vulgaris* 'Spring Glow' failed to root and subsequently died. A period of hardening off after lighting before harvesting cuttings may be beneficial and would still allow cuttings to be taken 6-8 weeks earlier than from plants grown in natural daylight.

Heather: rooted cuttings

- The growth of rooted cuttings of a range of heather cultivars was significantly advanced by growing under 16 and 22 hour photoperiods, allowing for sale/potting several weeks earlier than those grown in natural daylight/daylength.

Clematis: stock plants

- Photoperiod extension advanced the growth of *C.* 'Ernest Markham' and *C.* 'Jackmanii Superba', allowing cuttings to be taken a month earlier than from plants grown in natural daylight/daylength.

Rhododendron liners

- The effect of photoperiod on the growth and flowering of budded liners of a range of *Rhododendron* cultivars was inconsistent: shoot growth was advanced on some subjects at the expense of flowering, e.g. *R.* 'Snow Lady' whilst flowering was delayed on others, e.g. *R. pemakoense*.

Alpines

- The growth and flowering of plants of *Campanula* 'White Clips' and *Dianthus* 'Joy' and 'Whatfield Gem' was advanced in 16 and particularly 22 hour photoperiods.

- Two foliar sprays of 'Bonzi' applied at 1.2 ml/litre at 23 day intervals improved the

- Two foliar sprays of 'Bonzi' applied at 1.2 ml/litre at 23 day intervals improved the compactness of plants of *C.* 'White Clips' grown under lights.

RECOMMENDATIONS FOR FURTHER WORK

- The growth of stock plants of a wider range of heather species/cultivars under extended photoperiods requires evaluation; together with the time of introduction to lights, and the effect of hardening off plants prior to taking cuttings.

- The potential for 'Bonzi' for growth control of *Dianthus* grown under lights should be investigated further, along with other growth regulators e.g. chlormequat.

APPENDIX I

Contract, Schedule, Terms and Conditions