Project title:	Collaborative research programme in partnership with Saxon State Institute for Agriculture, Pillnitz, Germany for the development of 'new' ornamental plants for early season sales. Part II: Scheduled production and quality improvement.
Project number:	PC 267
Project leader:	Wayne Brough, ADAS
Report:	Final report, September 2007
Previous report:	(PC 247)
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Date completion due:	31 August 2007
Key words:	New pot plants, perennial plants, forcing, supplementary lighting, photoperiodic lighting, vernalisation, early season sales, plant growth regulators

The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results obtained have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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Grower Section

Headline

25 of the 34 herbaceous perennial species/varieties trialled, produced a successful flowering product suitable for early spring pot plant production by manipulating light quantity, photoperiod and temperature. The use of growth regulators improved the habit of several species / varieties, however further work is required to explore the optimum timing of applications.

Background and Expected Deliverables

This project builds on the information gained from previous projects undertaken at Pillnitz, Dresden and the HDC funded project PC 247 'New ornamental plants for early spring sale' undertaken during 2005/06. This new project PC 267 is once again a partnership between the Horticultural Development Council, U.K. and Saxon State Institute of Agriculture in Pillnitz, Germany.

In recent years several plant breeding companies have worked on developing new products for early season sales and improving the quality of perennial species currently available. As the number of available potential plant species increases, it offers growers in the UK and Germany other possible products to grow instead of (or to compliment) primroses and pansies during the early spring period. However, the knowledge about the new species is often insufficient. (For example, Michigan State University has studied the flowering requirements of a wide range of perennials for many years, but the information is specific to production under the environmental conditions experienced in America). As a consequence there is a need to develop a sufficient level of knowledge to permit the commercial scheduling of perennial plants under UK and European conditions.

The results of the previous project highlighted that the most important environmental cues for growth and flowering in perennial species were light quantity, photoperiod and vernalisation. The better the understanding of the interaction between the environment and the species in question, the more detailed and practical the information will be. The overall objective of this research project was to assist growers in the U.K and Germany to improve their economic returns and develop the market for early season sales (from Valentine's Day to March) of pot plants. The project built on the following areas -

- Enlargement of the assortment of new plant species grown for early spring sale
- Improvement of crop scheduling methods
- Creation of production blueprints for the most promising species / varieties
- Provision of advice for selling mixed containers of early spring species
- Improvement of plant quality via the use of chemical growth regulators
- An economic evaluation of the new product
- Consideration of customers interests especially product performance, shelf life under living room conditions and shelf life under outdoor conditions (frost-hardiness test).

Summary of the Project and Main Conclusions

34 species of perennials and biennials were grown for the early spring trial (2006/2007). 22 species were grown from seed and 12 species were grown from cuttings at the research station Dresden-Pillnitz in Germany. All the plants were potted up into 10 cm pots.

After potting, the plants were grown under outdoor conditions to aid establishment and to allow the plants to bulk up whilst under environmental conditions conducive to vegetative growth. From week 41 the plants were then either grown in an unheated polythene tunnel or in a frost-free glasshouse to permit vernalisation in the cooler temperatures. Forcing commenced in week 50 in four glasshouse compartments with different lighting treatments (two supplementary, a photoperiodic and an ambient light treatment). A second set of plants were forced from week 01 in two glasshouse compartments with the same supplementary lighting treatments but different temperatures. Two plant growth regulators (Chlormequat (CCC) 720 and Topflor) were applied at two different rates / application frequencies to a number of species from week 50 in four glasshouse compartments with different lighting treatments.

The following data was recorded for each plant in the trial:

- Date of flowering
- Height of leaves in cm
- Height of flower in cm
- Number of flowers per plant
- Number of buds per plant

- Number of branches per plant
- General value (rating 1 to 9)

Product shelf life under living room conditions (using a shelf life room) and the frost-hardiness of species at different temperatures in controlled climate chambers for 48 hours (+ 3°C; 0°C; - 3°C; - 6°C and darkness) were also examined as part of the trial. The shelf life in days, was recorded and notes were taken to record the reason for the discarded plant. The frost hardiness was evaluated shortly after removal from climate chamber and 4 days later.

The results obtained for the main species / varieties are summarised in the following table. Further specific detail and images for each species can be obtained from the main report.

From the 34 plant species / varieties tested, 25 species were suitable for cultivation as early spring pot plants. A selling date of Valentine's Day was achievable for most species when supplementary light was used. Supplementary lighting not only advanced the crop but also improved plant quality. Some species like Papaver and Calceolaria only flowered under photoperiodic or supplementary lighting. However, other plant species were able to flower at Valentine's Day when exposed to photoperiodic light or even ambient daylight (provided the right pre-cultivation measures had been undertaken). These species included: *Ajuga reptans* 'Mini Mahagoni', *Androsace septentrionalis* 'Star Dust', *Aquilegia* hybrida 'F1 Spring Magic' series, *Erysimum perovskianum* 'Goldrush', *Geum coccineum* 'Cooky', *Lindernia* 'Grandiflora' and *Phlox divaricata*.

Summary of results by species from the early spring trial undertaken at Pillnitz during 2006/2007

Species	Pot size (cm)	Potting week (latest)#	Daylength response	Vernalisation requirement and period	Storage method	Forcing treatment*	Growth regulation (CCC 720)	Shelf life (days)
Aujga pyramidalis 'Metallica Crispa'	9	31	Day-neutral	Yes 6-9 weeks	Poly tunnel or glasshouse	Supplementary light	nt	19-39
Ajuga reptans 'Braunhertz'	9/10	31	Day neutral	Yes 6-9 weeks	Poly tunnel or glasshouse	Supplementary light	nt	21-31
Ajuga reptans 'Mini Mahagoni'	9	33	Day neutral	Yes 6-9 weeks	Poly tunnel or glasshouse	Supplementary light	nt	29
Anacyclus pyrethrum var. depressus 'Silberkissen'	9/10	36	?	?	Poly tunnel or glasshouse	Supplementary light	+	14-26
Androsace septentrionalis 'Star Dust'	9/10	32-33	Day neutral	Yes ?	Poly tunnel or glasshouse	Supplementary light	0	23
Aquilegia hybrida 'F1 Spring Magic series	9/10	36	Day neutral	Yes 6-9 weeks	Glasshouse	Supplementary photoperiodic ambient	nt	15-26
Aquilegia vulgaris 'Winky Double White-White'	9/10	36	Day neutral	Yes 6-9 weeks	Glasshouse	Supplementary photoperiodic ambient	+	19-26
Calceolaria biflora 'Goldcap'	9/10	35	Long day	?	Poly tunnel or glasshouse	Supplementary light	nt	21-31
Erigeron karvinskianus 'Stallone'	9/10	36	?	?	Glasshouse	Supplementary light	+	25-32
Erysimum perovskianum 'Goldrush'	9	36	Day neutral	Yes 9 weeks?	Poly tunnel or glasshouse	Supplementary light	nt	19-39
Geum coccineum 'Cooky'	9/10	36	Day neutral	Yes 10 weeks	Poly tunnel or glasshouse	Supplementary light	+	11-15
Horminum pyrenaicum	9	28	?	Yes 10 weeks	Poly tunnel or glasshouse	Supplementary light	+	11-22

Species	Pot size (cm)	Potting week (latest)#	Daylength response	Vernalisation requirement and period	Storage method	Forcing treatment*	Growth regulation (CCC 720)	Shelf life (days)
Iberis sempervirens ‘Snowflake’	8-9	32	Day neutral	Yes 8-9 weeks	Poly tunnel or glasshouse	Supplementary light	nt	11-14
Lindernia ‘Grandiflora’	9	31	Day neutral	?	Glasshouse	Supplementary photoperiodic ambient	nt	38-47
Lithodora diffusa ‘Heavenly Blue’	9/10	30	Day neutral	Yes 9-10 weeks	Poly tunnel	Supplementary photoperiodic ambient	+	14-19
Papaver miyabeanum ‘Pacino’	9/10	32	Long day	?	Poly tunnel or glasshouse	Supplementary light	+	7-15
Papaver nudicaule ’Garden dwarf’	10	32	Long day	?	Poly tunnel or glasshouse	Supplementary light	0	11-15
Phlox divaricata	10	32	Day neutral	Yes 9 weeks	Poly tunnel or glasshouse	Supplementary light	+	19-22
Serissa foetida ‘Pink Mystic’	9	31	Day neutral	?	Glasshouse	Supplementary photoperiodic ambient	nt	19-24
Silene pendula ‘Lausitz’	10	31	Day neutral	Yes 6 weeks	Poly tunnel or glasshouse	Supplementary ambient	++	11-21

Key

Mid February onwards target marketing period.
* Optimal treatment for early marketing period. Although photoperiodic and ambient lighting may induce flowering, the flowering period is later relative to the supplementary lighting treatment.
Growth regulation with CCC 720 - 0 = no reaction, + = low to moderate inhibition effect, ++ = strong inhibition effect, nt = not tested

The use of growth regulators like Topflor and CCC 720 to control plant habit and growth was possible using the correct application rate / frequency. Each species reacted differently to the growth regulators and the response was also governed by the developmental stage of the plant and the forcing conditions to which the plants were exposed.

There was a need for sufficient vernalisation before the forcing treatments commenced otherwise fewer flowers were produced, the flower stems did not elongate adequately above leaves, plant quality suffered and the period of forcing was extended. High temperatures during the storage period in the autumn and early winter can become a problem for successful growing (when using polythene tunnels or cold glasshouses). The early spring trials (2006/2007) in Dresden-Pillnitz and STC (UK) were strongly influenced by the high temperatures during storage 2006. A recommendation for future work on early spring pot plants could be the use of cold stores to satisfy the vernalisation requirement of the plants.

The changing climatic conditions in terms of temperatures and light quantity from year to year can make it difficult to schedule the crop to an exact marketing date under ambient conditions. However, the trial has shown that with adapted temperatures and supplementary lighting, crop scheduling is possible for a range of species.

Financial Benefits

A detailed economic evaluation is provided within the main report, covering nine example production regimes. The main objective was to try and create a new crop that would fit in between current production programmes and provide a greater return to growers than the crops currently marketed through February and March.

Originally it was envisaged that the new crops could be produced without the need for supplementary light and under low forcing temperatures (around 10ºC). Work undertaken at Pillnitz and STC has shown this not to be the case and supplementary lighting and forcing temperatures of 12°C (with an initial temperature boost) are required. This is therefore a crop that once fitted into a production could be used to offset the cost of the supplementary lights alongside other crops, but it is questionable whether the crop alone would support the installation cost of new lighting equipment.

From the examples detailed in the report, net margins of Euros 34-178 per thousand plants were calculated (excluding the ambient light example). From trials with local floral outlets around Pillnitz, Dresden through 2007 an average retail price of Euros 2.30 was obtained for the product (the maximum price achieved was Euros 3.25).

Action Points for Growers

The main report provides treatment detail for each plant species tested under the environmental conditions experienced in continental Europe, work is underway to verify the results obtained under UK conditions. A number of general principles have emerged from the work undertaken at Pillnitz and these include:

- A pot size of 9-10cm is sufficient for most species, larger pot sizes can be used if several seedlings / rooted cuttings are used.

- Ensure plants are potted at the correct time so that sufficient growth is made prior to the storage treatment, (potting week varies from 28 to 36 depending upon species).

- Some plants such as Lithodora require trimming during the growing on phase to improve plant habit.

- For an early marketing period, the storage phase needs to commence around weeks 40-42.

- Ensure the correct storage treatment method is selected, some species respond better to storage in a polythene tunnel than a cold glasshouse. For other species (or to ensure a more uniform level of vernalisation) storage in a cold store may be the most appropriate method.

- Although no optimum vernalisation temperature was provided, temperatures need to be sufficiently low enough to induce flowering. Temperatures around 3-4ºC were assumed to be sufficient for vernalisation, although a small number of plant species examined in the trial were damaged by these low temperatures.

- Ensure a sufficient period is allowed for vernalisation to occur, several of the species need a basic period of around 6 weeks others need a longer period, up to 9 weeks or more.

- For an early marketing period, forcing needs to commence from around week 50 onwards.

- The higher initial forcing temperatures used this year (72 hours at day/night temperatures of 20ºC/18°C, venting at 22º/22°C) worked well. Temperatures of day/night 12°C/12°C, venting day/night 14°C/14°C can then be subsequently used to the point of flowering.

- Although some species will flower under photoperiodic treatment or ambient conditions, supplementary lighting is required to produce a good quality, uniform crop for a target marketing period of mid February to mid March.

- As an alternative to the standard supplementary lighting treatment (20 hours at 3000 lux) a light sum treatment of 80 klxh performed well. Although this treatment saved on electricity, the oil costs were higher, relative to the 20 hours supplementary light treatment, as the plants took longer to come into flower.

- Growth regulators (chlormequat was used in the trial) can be used to improve the habit of some plant species especially when exposed to supplementary lighting.

Science Section

1.0 Introduction

The second part of the collaborative research programme 'New ornamental plants for early season sale' builds on the information gained from previous projects including 'Development of alternative crops for spring sales' (Pillnitz 2000 – 2003) and the HDC funded project PC 247 'New ornamental plants for early spring sale part I' (Pillnitz and STC 2005 to 2006). This new project PC 267 (2006 to 2007) is once again a partnership between the Horticultural Development Council, U.K. and Saxon State Institute of Agriculture in Pillnitz, Germany.

In recent years several plant breeding companies have worked on developing new products for early season sales and improving the quality of perennial species currently available. As the number of available potential plant species increases, it offers growers in the UK and Germany other possible products to grow instead of (or to compliment) primroses and pansies during the early spring period. However, the knowledge about the new species is often insufficient. Michigan State University (Cameron et al, 1996) for example has studied the flowering requirements of a wide range of perennials for many years, but the information is specific to production under the environmental conditions experienced in America. As a consequence there is a need to develop a sufficient level of knowledge to permit the commercial scheduling of perennial plants under UK and European conditions.

The results of the previous project (PC 247) highlighted that the most important environmental cues for growth and flowering in perennial species were light quantity, photoperiod and vernalisation. The better the understanding of the interaction between the environment and the species in question, the more detailed and practical the information will be for use by growers. The overall objective of this research project (like last year) was to assist growers in the U.K and Germany to improve their economic returns and develop the market for early season (from Valentine's Day to March) sales of pot plants. PC 267 built on the following areas -

- Enlargement of the assortment of new plant species grown for early spring sale
- Improvement of crop scheduling methods
- Creation of production blueprints for the most promising species / varieties
- Provision of advice for selling mixed containers of early spring species
- Improvement of plant quality via the use of chemical growth regulators
- An economic evaluation of the new product
- Consideration of customers interests especially product performance, shelf life under living room conditions and shelf life under outdoor conditions (frost-hardiness test).

2.0 Materials and Methods

2.1 Early spring trial 2006/2007

34 species of perennials and biennials were grown for the early spring trial (2006/2007). 22 species were grown from seed and 12 species were grown from cuttings at the research station Dresden-Pillnitz. All the plants were potted up into 10 cm pots. The list of the 34 plants species, their source of origin, plant type and whether they were included in the plant growth regulator trial is presented in Table 1.

Table 1: Origin, species, plant type and inclusion in the plant growth regulator trial (PGR Trial) of plant material used in the in the early spring trial (2006/2007)

Source	Species	Plant Types	PGR Trial
Jal	*Ajuga pyramidalis* 'Metallica Crispa'	p	
Jal	*Ajuga reptans* 'Braunhertz'	p	
Jal	*Ajuga reptans* 'Mini Mahagoni'	p	
Jal	*Arabis ferdinandi* 'Coburgii Variegata'	p	
Jal	*Arabis ferdinandi* 'Old Gold'	p	
Jal	*Cymbalaria* 'Muralis'	p	
Jal	*Iberis sempervirens* 'Snowflake'	p	
Jal	*Lindernia* 'Grandiflora'	p	
Jal	*Lithodora diffusa* 'Heavenly Blue'	hs	x
Jal	*Lithodora diffusa* 'Pete's Favorite'	p	
Jal	*Serissa foetida* 'Pink Mystic'	s	
bGD	*Phlox divaricata*	p	x
bGD	*Phlox divaricata* (propagation material Pillnitz)	p	x
Jal	*Ajuga reptans* 'Mini Mahagoni' (propagation Pillnitz)	p	
Je	*Anacyclus pyrethrum* var. depressus 'Silberkissen'	p	x
LfL	*Androsace septentrionalis* 'Star Dust'	b	x
Be	*Aquilegia hybrida* 'F1 Spring Magic Blue'	p	
Be	*Aquilegia hybrida* 'F1 Spring Magic light red – yellow'	p	
Be	*Aquilegia hybrida* 'F1 Spring Magic light red – white'	p	
Be	*Aquilegia hybrida* 'F1 Spring Magic navy blue – white'	p	
Be	*Aquilegia hybrida* 'F1 Spring Magic pink - white'	p	
Be	*Aquilegia hybrida* 'F1 Spring Magic white'	p	
Kieft	*Aquilegia vulgaris* 'Winky Double White- White'	p	x

Source	Species	Plant Types	PGR Trial
Kieft	*Barbarea rupicola* ‘Sunnyola’	p	
Kieft	*Calceolaria biflora* ‘Goldcap’	p	
Kieft	*Erigeron karvinskianus* ‘Stallone’	p	x
Je	*Erinus alpinus* ‘Dr. Hähnle’	p	
Kieft	*Erysimum perovskianum* ‘Goldrush’	p	
Be	*Geum coccineum* ‘Cooky’	p	x
Je	*Horminum pyrenaicum* ‘Rubrum’	p	
Je	*Horminum pyrenaicum*	p	x
Je	*Lychnis alpina*	p	x
Je	*Lychnis alpina* ‘Snow Furry’	p	x
Be	*Papaver miyabeanum* ‘Pacino’	p	x
Be	*Papaver nudicaule* ’Garden dwarf’	p	x
LfL	*Silene pendula* ‘Lausitz’	b	x

Key to terminology:

Be	– Benary	bGD	– Botanical Garden Dresden
Je	– Jelitto Seeds	Jal	– Jaldety Israel
Kieft	– Kieft Seeds	LfL	– Saxon State Institute of Agriculture
p	– perennial	b	– biennial
s	– shrub	hs	– half-shrub
x	– examined in the PGR trial		

After potting, the plants were grown under outdoor conditions to aid establishment and to allow the plants to bulk up whilst under environmental conditions conducive to vegetative growth. From week 41 the plants were then either grown in an unheated polythene tunnel or in a frost-free glasshouse to permit vernalisation in the cooler temperatures. Forcing commenced in week 50 in four glasshouse compartments with different lighting treatments. A second set of plants were forced from week 01 in two glasshouse compartments with the same supplementary lighting treatment but different temperatures. The PGR trial was applied to a number of species from week 50 in four glasshouse compartments with different lighting treatments. When there was sufficient plant material, the plants were grouped into three replicates with 16 plants per plot. The two middle rows of 8 plants were used for data collection. When there was insufficient plant material a minimum of 8 plants per plot were used. The PGR trial had no replications per variant. The plants were spaced at about 32 plants/m². The production and treatment diary is presented in Table 2.

Table 2: Production and treatment diary for early spring trial 2006/2007

Week	Date	Location	Treatment
27		Glasshouse (H 14.2)	Sticking cuttings from Jaldety in QP 40 trays, substrate: Brill type 3, Lithodora in mixture of peat and sand 1:1, small polythene tunnel used for rooting, first watering with Previcur N 0.15%
29		Glasshouse (H 14.1)	Sowing of seed propagated species, substrate: Brill for propagation, first watering with Previcur N 0.15%, placed into cold store at 8°C to germinate
31-34		Glasshouse (H 14.1+ H 14.7+14.8)	Pricking out of seedlings in QP 40, substrate: D400 with Xylit SMLfL
32	9 Aug 06	Outdoor	Outdoor beds prepared
31-38		Outdoor	Potting on of rooted seedlings and cuttings (plugs) into 10 cm pots, substrate: Gramoflor for primroses, Lithodora in substrate mixture: D400 with Xylit SMLfL and peat 1: 1
39	28 Sept 06	Outdoor	Fertiliser applied – 0.1% Ferty 3 green (15-10-15)
39	26 Sept 06	Outdoor	0.035% Confidor WG 70+ 0.15% Polyram WG+ 0.2% Aminosol
41		Polythene tunnel and glasshouse (H 14.2 + 14.3+ 14.4 + H 13.2)	Plants moved into unheated polythene tunnel or cold glasshouse for vernalization. In the glasshouse day / night: heating at 2ºC and venting at 4ºC; in the polythene tunnel venting started at 8-10ºC
41	11 Oct 06	All locations	0.2% Dithane Ultra+ 0.02% Discus + 0.2% Wuxal Amino
44		Polythene tunnel and glasshouse (H 14.2 + 14.3+ 14.4 and H 13.2)	First flowers and buds removed from some species
45	9 Nov 06	Polythene tunnel and glasshouse (H 14.2 + 14.3+ 14.4 + H 13.2)	Trimming of Iberis, Phlox, Lithodora, Erigeron and Cymbalaria
46	17 Nov 06	All locations	Fertiliser applied – 0.2% Ferty 3 green (15-10-15)
49	7 Dec 06	All locations	0.20% Dithane+ 0.1% Ortiva + 0.2% Aminosol + 0.02% Masai
50	11 Dec 06	Glasshouse compartments (H 11.1, 11.2 ,11.3, 10.3)	Plants placed into different forcing treatments.
50	12 and 15 Dec 06	Glasshouse compartments (H 11.1, 11.2 ,11.3,	From Tuesday to Friday (approx 72 hours) plants pushed with higher temperatures heating day/night

Week	Date	Location	Treatment
		10.3)	20ºC/18°C, venting at 22º/22°C and lighting treatments start: H 11.1: Supplementary lighting – 3000 lux, 20 hours, 4.00-24.00 = 0.13 mol/m²; 8.13 W/m² PAR. H 11.2: Supplementary lighting – 80 klxh, 3000 lux, 4.00-24.00 = 265 Wh/m² PAR H 11.3: Photoperiodic lighting – 100 lux / m², 20 hours, 4.00-24.00 = 0.0044 mol/m²; 0.275 W/m² PAR. H 10.3: Ambient daylight (from sunset to sunrise the plants were covered to protect them from light spillage from other treatments) Fertiliser with each watering 0.05% Ferty 3 green (15-10-15-2) EC = EC water + EC fertilizer = 0.4 + 0.8=1.2
50	15 Dec 06	All glasshouse compartments	Back to lower temperatures heating day/night: 12ºC and venting 14ºC
50		All glasshouse compartments	0.3% Neem Azal + 0.2% Aminosol
51	18 Dec 06	All glasshouse compartments	Old foliage removed from plants
51	21 Dec 06	All glasshouse compartments	0.20% Dithane + 0.04% Plenum + 0.10% Aminosol
52	28 Dec 06	All glasshouse compartments	PGR Trial: 0.10% and 0.05% Topflor at 80 ml/m² 0.20% and 0.10% CCC 720 at 100 ml/m²
1	2 Jan 07	Glasshouse compartments (H 10.1, 10.2)	Second set of plants placed into different treatments. From Tuesday to Saturday (approx 72 hours) plants pushed with higher temperatures heating day/night 20ºC/18°C, venting at 22º/22°C and lighting treatment begins: Supplementary lighting treatment – 3000 lux, 20 hours, 4.00-24.00 = 0.13 mol/m²; 8.13 W/m² PAR; Fertiliser with each watering 0.05% Ferty 3 green (15-10-15-2) EC = EC water + EC fertilizer = 0.4 + 0.8=1.2
1	6 Jan 07	Glasshouse compartments (H 10.1, 10.2)	H 10.1: Temperatures heating day/night 12°C/12°C, venting day/night 14°C/14°C H 10.2: Temperatures heating day/night 9°C/9°C, venting day/night 12°C/12°C
1		Glasshouse compartments (H 11.1, 11.2 ,11.3, 10.3)	0.15% Previcur N applied to Horminium pyrenaicum

Week	Date	Location	Treatment
1	3 Jan 07	Glasshouse compartments (H 11.1, 11.2 ,11.3, 10.3)	PGR Trial: 0.05% Topflor at 80 ml/m² 0.10% CCC 720 at 100 ml/m²
2		Glasshouse compartments (H 10.1, 10.2)	Old foliage removed from plants
2	9 Jan 07	Glasshouse compartments (H 11.1, 11.2 ,11.3, 10.3)	PGR Trial: 0.10% and 0.05% Topflor with 80 ml/m² 0.20% and 0.10% CCC 720 with 100 ml/m²
2	11 Jan 07	All glasshouse compartments	0.10% Rovral + 0.035% Confidor + 0.20% Aminosol
3	16 Jan 07	Glasshouse compartments (H 11.1, 11.2 ,11.3, 10.3)	PGR Trial: 0.05% Topflor with 80 ml/m² 0.10% CCC 720 with 100 ml/m²
4		All glasshouse compartments	Fertiliser applied – 0.2% Ferty 3 green (15-10-15)
4		Glasshouse compartments (H 10.1, 10.2)	0.2% Dithane+ 0.04% Plenum + 0.10% Aminosol
7	16 Feb 07	All glasshouse compartments	0.1% Ortiva (powdery mildew)

Key to products:
Discus – kresoxim-methyl 500g/l, Masai – tebufenpyrad, Confidor imidacloprid, Plenum 50 WG – pymetrozine, Polyram WG – metiram, Previcur N – propamocarb, rovral – iprodione, Dithane Ultra – mancozeb, Ortiva – azoxystrobin 250g/l, Topflor – flurprimidol, CCC 720 – chlormequat, Wuxal Amino – 700g/l amino acid (9% nitrogen), Neem Azal T/S – Azadirachtin (Neem) (Note German not UK approved status).

2.2 Plant growth regulator trial

The first growth regulator treatments were applied in all the glasshouse compartments in week 52 (supplementary light, photoperiodic light and ambient daylight treatments). The treatments were either applied two or four times. In Germany, only two applications of Topflor and chlormequat (CCC) 720 are permitted at the higher rates (0.20% at 100 ml/m² for CCC 720 and 0.10% at 80 ml/m² for Topflor). The two applications were made in weeks 52 and 2. To apply four treatments, the rates were divided in half and treatments were applied during weeks 52, 1, 2 and 3 with 0.10% CCC 720 applied at 100 ml/m² and 0.05% Topflor applied at 80 ml/m². The following table (Table 3) summarises the treatments. The growth regulators were tested on 11 species, which are listed in Table 1.

Table 3: Growth regulator treatments applied during the PGR trial

Treatment	Application week	Volume per m^2
0.20 % chlormequat 720	52 and 2	100 ml
0.10 % chlormequat 720	52; 1; 2 and 3	100 ml
0.10 % Topflor	52 and 2	80 ml
0.05 % Topflor	52; 1; 2 and 3	80 ml

Key to products: Topflor – flurprimidol, CCC 720 – chlormequat.

In all the glasshouse compartments for both trials, the plants were monitored every second or third day during the forcing period. If one plant fulfilled the specific criteria for flowering, the measurements and ratings were carried out. Eight plants from each plot were measured wherever possible and the following records were taken:

- Date of flowering
- Height of leaves in cm
- Height of flower in cm
- Number of flowers per plant
- Number of buds per plant
- Number of branches per plant (lithodora)
- General value (rating 1 to 9, 1 = very bad; 5 = middle; 9 = perfect)

During the trial environmental conditions including temperature, air humidity and irradiation levels were recorded by a data logger. Appropriate visual observations on each plant species (e.g. disease presence) were also documented.

Digital images were taken which show the plant species in different factorial combinations after planting, at the beginning of storage, at the beginning of forcing and at flowering.

The data were analysed with help of the statistic program SPSS. With the two factor analysis of variance, the significances of the single factors were determined as well as the interactions between the factors. The averages of data were compared by BONFERRONI test (with $\alpha = 0.05$). This test is more accurate than other multiple average tests because of the slightly different numbers of plots in the trial. All data from the trials and the most important results of the analysis by SPSS program were saved on a CD, which is contained in the annex.

2.3 Shelf life under living room conditions and frost hardiness test

Product shelf life under living room conditions and the frost-hardiness of species at different temperatures in controlled climate chambers for 48 hours (+ 3°C; 0°C; - 3°C; - 6°C and darkness) were also examined as part of the trial. (Flowering plants were selected either directly from the glasshouse compartment or after completion of the shelf life test to examine them for frost hardiness). The shelf life test was run under the following conditions - artificial light at 300 – 500 lux daily for 12 hours = 0.022 mol/m^2; 1.375 W/m^2 PAR, temperature 20°C – 22°C and air humidity 40 % - 60 %.

The watering was carried out via glass fibre (from a jar of water to the growing media directly).

The shelf life in days, was recorded and notes were taken to record the reason for the discarded plant. The frost hardiness was evaluated shortly after removal from climate chamber and 4 days later.

2.4 Temperatures and light conditions

It is important to recognize the climatic variation that exists between conditions in the U.K. and those at Pillnitz, Germany. The following data collected during the trial period at Pillnitz can be used to compare with UK growing conditions.

Average monthly temperatures for Pillnitz from 2001 to 2007 are presented in Figure 1.

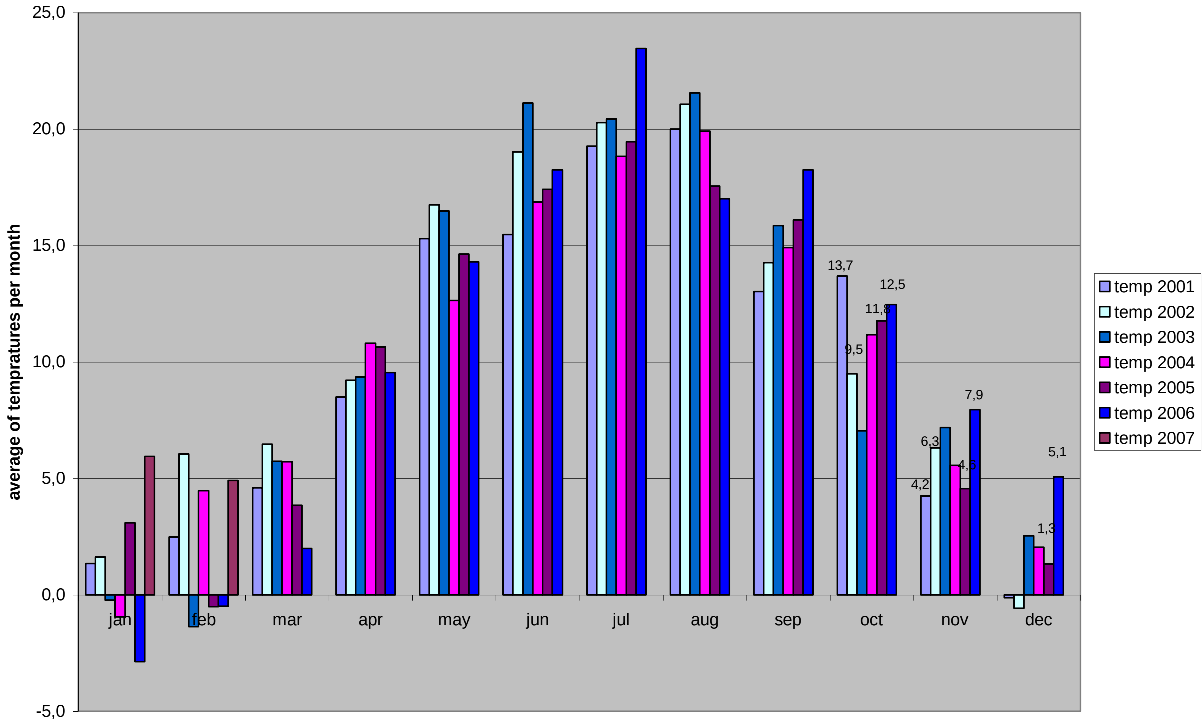

Figure 1: Average temperatures per month in different years

Table 4 shows the sum of average outdoor temperatures from the 6 October to the 11 December 2001, 2002, 2005 and 2006. The comparison shows that the autumn of 2006 was extreme in term of temperatures. The sum of average temperatures was 40% higher than the average of the other years. The warm temperatures were useful for plant growth and compensated for the late potting date but there was not enough time for effective vernalisation in the case of some plant species.

Table 4: Sum of average temperature outdoor at Pillnitz in autumn 2001, 2002, 2005, 2006

Autumn	Sum of temperatures from averages per days in °C x days from 6 October to 11 December
2001	483.7
2002	414.4
2005	459.1
2006	635.8

Table 5 summarises the temperatures in all trial environments in the early spring trial (2006/2007). In the polythene tunnel, there were only 11 days that had temperatures below 4°C, compared to the years 2001, 2002 and 2005 when the plants had on average 70% more days below 4°C (about 40 days) during storage in the polythene tunnel. An interesting fact is that plants from the second forcing week (01) in 2007 were able to accumulate more days of lower temperatures to satisfy their vernalisation need.

Table 5: Temperature conditions at Pillnitz in the early spring trial 2006/2007

Location	**Sum of temp. from averages per days in °C x days 11 Oct to 11 Dec 2006 (week 50)**	**Days with temp. below 4°C**	**Days with temp. below 3°C**	**Days with temp below 0°C**
H13.2	650.9	0	0	0
H14.2	658.8	0	0	0
H14.3	637.7	4	0	0
H14.4	611.8	6	0	0
Polythene tunnel	618.5	11	8	3
Location	**Sum of temp. from averages per days in °C x days 11 Oct 2006 to 2 Jan 2007 (week 01)**	**Days with temp. below 4°C**	**Days with temp. below 3°C**	**Days with temp below 0°C**
H14.3	788.2	7	0	0
H14.4	747.8	16	0	0
Polythene tunnel	725.2	29	24	6

During the forcing period, the four glasshouse compartments were exposed to different amounts of light. This is illustrated in Figure 2 which shows that the plants under supplementary lighting in glasshouse compartment H 11.1 (20h-3000lx) received about 40% more light up to Valentine's Day compared to the photoperiodic and ambient daylight treatments. The glasshouse compartment with the light sum collection H 11.2 (80klxh) received 12% less light up to Valentine's Day compared to H 11.1 (20 h – 3000 lx). The average number of hours illumination until Valentine's Day in glasshouse compartment H 11.1 was 18:26 hours, whilst in glasshouse compartment H 11.2 it was 13:20 hours. This is an average difference of 5 hours illumination per day. The plants from the second forcing received a light level of 262.8 mol/m² PAR in the two glasshouse compartments H 10.1 and H 10.2 up to Valentine's Day and then 362.3 mol/m² PAR one week later on 25 Feb 07 (week 8).

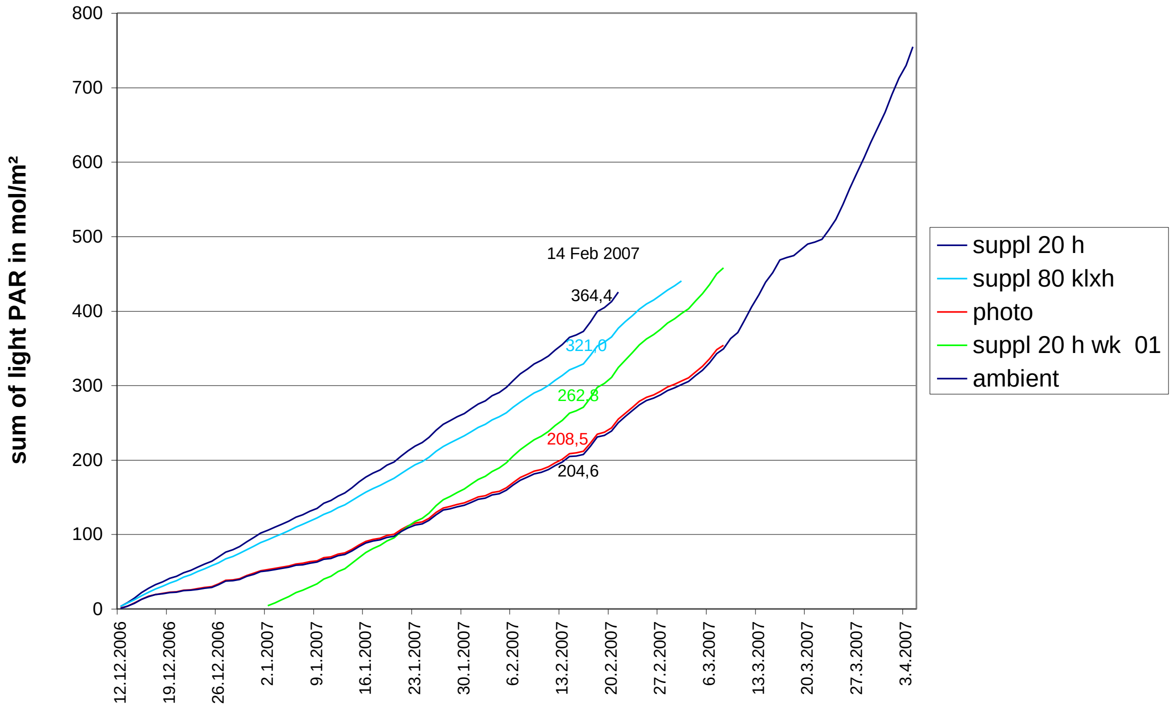

Figure 2: Development of light summaries in the different light treatments

In the glasshouse compartment with supplementary light, the temperature was a little higher because of the radiation from the lamps.

<u>Sum of temperatures from 12 December to the 14 February (65 days):</u>

Glasshouse 11.1 supplementary light 20h:	889.2 °C x days
Glasshouse 11.2 supplementary light 80klxh:	878.2 °C x days
Glasshouse 11.3 photoperiodic light :	841.5 °C x days
Glasshouse 10.3 ambient daylight:	854.3 °C x days

<u>Sum of temperatures from 2 January to 2 March (60 days)</u>

Glasshouse 10.1 supplementary light 20h and 12°C:	833.3 °C x days
Glasshouse 10.2 supplementary light 20h and 9°C:	727.2 °C x days

To compare results from different years it is helpful to compare the sum of temperatures. From the start of forcing, the average temperatures over 80 days were collected. The early spring trial (2006/2007) accumulated about 1060°C x days compared to the trial during 2002/2003 which accumulated only 870°C x days. In the year 2002/2003, the heating was 10°C and ventilation 12°C (as opposed to 12°C and 14°C), this makes an important difference over the forcing period. This seems to be the reason why some species flowered earlier than expected this year.

<u>The light treatments finished at different dates:</u>

Glasshouse 11.1 supplementary light 20h:	21 Feb 07	week 8
Glasshouse 11.2 supplementary light 80klxh:	2 March 07	week 9
Glasshouse 11.3 photoperiodic light:	8 March 07	week 10
Glasshouse 10.3 ambient daylight:	4 April 07	week 14
Glasshouse 10.1 supplementary light 20h and 12°C:	8 March 07	week 10
Glasshouse 10.2 supplementary light 20h and 9°C:	8 March 07	week 10

3.0 Results and Discussion

Due to the unusually warm weather conditions experienced through the trial period (and slightly higher forcing temperatures) many species flowered earlier than expected this year compared to results from previous years (2001 to 2003 and 2006). However, a few species performed worse (no flower, less flower or delayed flower) as a result of insufficient vernalisation (even the supplementary light treatment could not compensate for the lack of a cool period in some cases).

The storage period is an important part of the production programme. It is during this period that vernalisation occurs. The autumn / early winter period of 2006 was unusually warm. In autumn 2001 and 2002, the vernalisation received up to week 50 was sufficient for species like *Lychnis alpina* and *Erinus alpinus* to permit successful flowering, but not in 2006. The flowers on these plants during 2006 were not induced or did not elongate sufficiently above the leaves even with supplementary light.

There are still many questions to answer regarding the time and amount of degrees vernalisation required for each species. Michigan State University has done much research (Cameron et al 1996, Fausey, B.; Padhye, S.; Runkle, E. and Cameron, A. 2005 and 2006) on vernalisation especially with perennials. With a fixed temperature at 5°C (which was defined as the optimum for vernalisation), perennials were tested in a controlled environment chamber (with 25 to 50 foot-candle light levels) for 4 to 15 weeks. Generally plants came into flower after a vernalisation period of 4 to 6 weeks, but with more weeks of vernalisation, there was an improvement in a number of important flowering characteristics such as percentage of plants flowering, a reduction in the time to flower and an increase in flower number. Michigan State University tested a wide range of perennial species, their results will be mentioned, where relevant, later in this section when the reactions of individual plants species are described.

As with the previous trial, the main objective of the 2006 trial was again to produce marketable plants by Valentine's Day (14 February) or at least to finish the crop before the commencement of the bedding plant season. From the 34 tested species / varieties, 25 varieties produced a successful flowering product during the trial, whilst 9 varieties failed because of low marketable scores or insufficient flower during the trial period. Table 6 lists the successful species / varieties and Table 7 those that failed during this years trial. The successful species are covered in more detail later in the section. The first part of the section concentrates on species, which were not included in the PGR trial, the second covers those species which received growth regulators treatments. Not all the plants within each plot (minimum of 8 plants) had reached a flowering stage. The exact number is listed in the average table of the species in the CD annex.

Table 6: Successful species in the early spring trial 2006/2007

Species number	Species	General marketable score less than 4.9	Insufficient flower	Inclusion in PGR trial
F01	*Anacyclus pyrethrum* var. depressus 'Silberkissen'			x
F02	*Androsace septentrionalis* 'Star Dust'			x
F09	*Aquilegia vulgaris* 'Winky Double White- White'			x
F13 gest	*Erigeron karvinskianus* 'Stallone'			x
F16	*Geum coccineum* 'Cooky'			x
F18	*Horminum pyrenaicum*			x
15	*Lithodora diffusa* 'Heavenly Blue'			x
F21	*Papaver miyabeanum* 'Pacino'			x
F22	*Papaver nudicaule* 'Garden dwarf'			x
24	*Phlox divaricata*			x
26	*Phlox divaricata* (propagation Pillnitz)			x
F23	*Silene pendula* 'Lausitz'			x
3	*Ajuga pyramidalis* 'Metallica Crispa'			
4	*Ajuga reptans* 'Braunhertz'			
5	*Ajuga reptans* 'Mini Mahagoni'			
25	*Ajuga reptans* 'Mini Mahagoni' (propagation Pillnitz)			
F03	*Aquilegia hybrida* 'F1 Spring Magic blue - white'			
F04	*Aquilegia hybrida* 'F1 Spring Magic light red - yellow'			
F05	*Aquilegia hybrida* 'F1 Spring Magic light red -white'			
F06	*Aquilegia hybrida* 'F1 Spring Magic navy blue – white'			
F07	*Aquilegia hybrida* 'F1 Spring Magic pink - white'			
F08	*Aquilegia hybrida* 'F1 Spring Magic white'			
F12	*Calceolaria biflora* 'Goldcap'			
F15	*Erysimum perovskianum* 'Goldrush'			
13	*Iberis sempervirens* 'Snowflake'			
14	*Lindernia* 'Grandiflora'			
20	*Serissa foetida* 'Pink Mystic'			
6	*Arabis ferdinandi* 'Coburgii Variegata'	x		
7	*Arabis ferdinandi* 'Old Gold'	x		
F11	*Barbarea rupicola* 'Sunnyola'	x		
10	*Cymbalaria* 'Muralis'	x		
F13	*Erigeron karvinskianus* 'Stallone'	x		
F14	*Erinus alpinus* 'Dr. Hähnle'		x	
F17	*Horminum pyrenaicum* 'Rubrum'		x	
16	*Lithodora diffusa* 'Pete's Favorite'		x	
F19	*Lychnis alpina*		x	x
F20	*Lychnis alpina* 'Snow Furry'		x	x

Table 7 summarises the week number of flowering after forcing by species in response to the various lighting treatments. The similar range of flowering weeks recorded indicates that it is possible to grow a range of species for the same marketing date. Therefore, there is a good opportunity to produce mixed trays / containers for the same week of sale (Figures 3, 4 and 5).

Figure 3: week 04; mixed tray with 8 different early spring pot plants

Figure 4: week 04; arrangement for early spring sale with *Geum coccineum* 'Cooky'; *Papaver nudicaule* 'Garden Dwarf'; *Calceolaria biflora* 'Goldcap' and *Erysimum perovskianum* 'Goldrush'

Figure 5: week 08; floriga trade fair; Leipzig 2007; presentation to highlight the results

Table 7: Species, flowering week (when exposed to different lighting treatments) and vernalisation requirement

Species number	Species	Start of forcing; lighting; temperature and flowering by week number						vernalization required x = yes
		week 50* 20h 3000lx 12°C	week 50* 80klxh x 12°C	week 01* 20h 3000lx 12°C	week 01* 20h 3000lx 9°C	week 50* photoper. / 20h 100lx 12°C	week 50* ambient daylight 12°C	
3	*Ajuga pyramidalis* 'Metallica Crispa'	2-3	2 - 3	5 - 6	n.t.	(long period) 5 - 10	(long period) 9 - 13	x
4	*Ajuga reptans* 'Braunhertz'	4	4 - 6	6 - 7	7	9 -10	10 -12	x
5	*Ajuga reptans* 'Mini Mahagoni'	3 - 4	3 - 4	5 - 6	6 - 7	6 - 8	7- 9	x
F01	*Anacyclus pyrethrum var. depressus* 'Silberkissen'	5 - 6	5 - 6	7 - 8	8 - 9	8 - 9	10	?
F02	*Androsace septentrionalis* 'Star Dust'	2 - 3	2 - 4	3 - 4	4 - 5	(long period) 7 - 10	(long period) 7 - 10	x
F04	*Aquilegia hybrida* 'F1 Spring Magic light red - yellow'	2 - 3	3 - 4	4 - 5	5 - 6	6 - 8	8 - 10	x
F09	*Aquilegia vulgaris* 'Winky Double White- White'	4 - 5	5 - 6	8	n.t.	8 – 9	12 - 13	x
F12	*Calceolaria biflora* 'Goldcap'	4 - 5	6 - 7	7 - 8	9 - 10	8 - 9	no flower until week 14	?
F13 gest	*Erigeron karvinskianus* 'Stallone'	4 - 5	4 - 5	7 - 8	9 - 10	7 - 9	8 - 10	?
F15	*Erysimum perovskianum* 'Goldrush'	3 - 4	3 - 4	6 - 7	7 - 8	(long period) 5 - 10	(long period) 7 - 11	x
Species	**Species**	**Start of forcing; lighting; temperature and flowering by week number**						**vernalization**

number		week 50* 20h 3000lx 12°C	week 50* 80klxh 12°C	week 01* 20h 3000lx 12°C	week 01* 20h 3000lx 9°C	week 50* photoper. / 20h 100lx 12°C	week 50* ambient daylight 12°C	required x = yes
F16	*Geum coccineum* 'Cooky'	2 - 4	2 - 4	4 - 5	4 - 5	(long period) 4 - 10	(long period) 4 - 13	x
F18	*Horminum pyrenaicum*	3 - 4	5 - 6	8	8 - 9	9 - 10	14	x
13	*Iberis sempervirens* 'Snowflake'	3 - 4	3 - 4	6 - 7	7	7 - 9	(long period) 8 - 11	x
14	*Lindernia* 'Grandiflora'	1	1	4 - 7	4 - 9	1	4	?
15	*Lithodora diffusa* 'Heavenly Blue'	6 - 7	6 - 7	8 - 9	9	9 - 10	10 - 11	x
F21	*Papaver miyabeanum* 'Pacino'	3 - 4	3 - 4	6	6 - 7	(long period) 4 - 8	no flower until week 14	?
F22	*Papaver nudicaule* 'Garden dwarf'	2 - 3	3 - 4	5 - 6	6 - 7	(long period) 4 - 9	no flower until week 14	?
24	*Phlox divaricata*	3 - 4	3 - 4	6 - 7	7 - 8	(long period) 5 - 8	11 - 12	x
20	*Serissa foetida* 'Pink Mystic'	6 - 7	6 - 7	9 - 10	9 - 10	6 - 8	7 - 9	?
F23	*Silene pendula* 'Lausitz'	4 - 5	5 - 6	5 - 6	6 - 8	(long period) 6 - 9	(long period) 9 - 14	x

Key to terminology: n.t – not tested variant. (*) – with 72 hours forcing treatment at higher temperatures of 20°C

Growing the plants outdoors, under polythene (unheated) or under glass (frost protection) sometimes had a significant effect on th e plant species in question. Any effects recorded are covered under each individual species.

Most species were influenced by the lighting treatments. Supplementary lighting had the greatest effect bringing flowering time forward and improving plant marketability and overall quality.

All results shown as charts for all species including the influence of lighting on plant parameters, are included in the CD annex.

The stages of growth and development are collected in a ULEAD Photo Impact album and in a web browser readable slide show, which are saved on the CD in the annex.

3.1 Record by species (with no growth regulator treatments)

***Ajuga pyramidalis* 'Metallica Crispa'**
This species developed an attractive dark robust rosette of leaves. The blue colour of the flowers was attractive and the species looked good in arrangements. The compact plant has relatively short stolons (Figure 6). A 9 cm pot size would be more appropriate. The date of flowering was recorded when three open flowers were present on a flower stem.

Figure 6: Week 5; *Ajuga pyramidalis* 'Metallica Crispa'

<u>Forcing treatment:</u> All the plants exposed to supplementary lighting were 8 weeks earlier than plants exposed to ambient daylight. The storage treatment had no influence. The plants flowered after 30 to 32 days (Glasshouse components H 10.1, 11.1, H 11.2). There were no plants placed in H 10.2 (20h-9°C). The photoperiodic light had an effect only on the plants from the polythene tunnel (until week 10 - end of recording), plants from the polythene tunnel exposed to photoperiodic light were 4 weeks earlier than plants exposed to ambient daylight. In addition, plants exposed to ambient daylight from the polythene tunnel were two weeks earlier compared to plants from frost-free

glasshouse. This suggests that vernalisation may be necessary for Ajuga. The use of supplementary light appears to compensate for any lack of vernalisation. Only plants exposed to supplementary light flowered at Valentine's Day, all the plants from forcing week 50 were in flower by weeks 2 to 3 and all the plants from forcing week 01 were in flower by weeks 5 to 6.

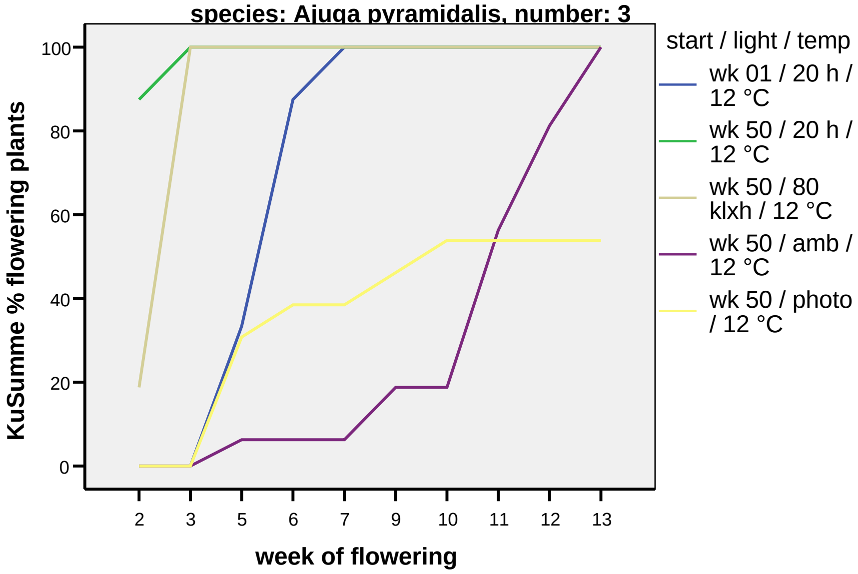

Figure 7: Percentage of flowering plants relative to the light treatments
(photoperiodic lighting treatment H 11.3 stopped in week 10)

Height of leaves, height of flowers and number of buds and flowers: There was no influence on leaf height and no mentionable influence on bud and flower number from the lighting or storage treatments. The plants from forcing week 01 that were exposed to supplementary light (especially plants from outdoors) had significantly taller flowers (an average difference of average 2cm) than those in the other glasshouse compartments. These plants received a greater number of 'cool days' relative to those plants from forcing week 50.

General value: Only the plants from the supplementary light treatment were marketable. The general value was around 6. The plants did not 'fill' the 10 cm pot.

Shelf life test: The shortest period of time was 19 days whilst the longest time was 39 days, with an average of 31 days. *Ajuga pyramidalis* 'Metallica Crispa' is suitable for living room conditions.

Recommendation for *Ajuga pyramidalis* 'Metallica Crispa': Cuttings root in about three weeks. Potting should occur by week 31 at the latest to make sure that one rosette can fill the pot and the plants are of a sufficient size prior to vernalisation. A 9 cm pot is adequate for this species. Ajuga needs to be well fed, nutritional levels should be at the higher level of 500 to 700mg N per plant. Plants require a cool period of about 9 weeks. This is important for flowering and flower height. Minimal cleaning is required prior to marketing. With higher forcing temperatures of 12°C and supplementary light, it is possible to sell the ajuga at Valentine's Day. With ambient daylight and temperatures of 10°C-12°C flowering will commence in the middle of March.

***Ajuga reptans* ‘Braun Hertz’**

This variety also had attractive blue flowers, the disadvantage however are the long stolons (Figure 10), therefore, the general value was low for single plant, but in the creation of arrangements, this crop could be still interesting. The colour of the leaves was different after different storage treatments as the following images (Figures 8 and 9) show. The bronze colour disappeared during forcing.

Figure 8 and Figure 9: week 50; *Ajuga reptans* ‘Braun Hertz’, storage: right polythene tunnel, left frost-free greenhouse

Forcing treatment: All the supplementary light treatments with 20hours - 3000lux (H 11.1+10.1+10.2) flowered in about the same time period (38-41 days). The flowering in glasshouse compartment H 11.1 from forcing week 50 was earlier than the 80klxh treatment (H 11.2). However, this delay was mainly because of the plants from the frost-free glasshouse required more vernalisation. All the plants from forcing week 50 came into flower before Valentine’s Day in week 4 to 6. Plants from forcing week 01 did not flower completely by weeks 6 to 7. Reasons for the lack of flower in some plants could be that the developed flowers were damaged and were cleaned off or that flowering was not induced (although these plants experienced more cool days). Plants exposed to photoperiodic light and ambient daylight were later (weeks 10 to 11) and not all the plants flowered until week 14 (Figure 11).

Figure 10: week 04; *Ajuga reptans* 'Braun Hertz'

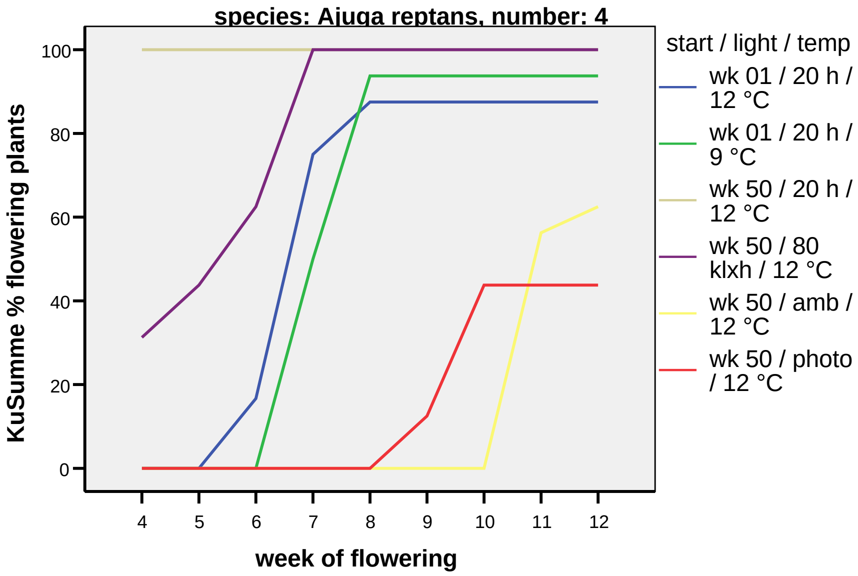

Figure 11: Percentage of flowering plants relative to the light treatments
(photoperiodic lighting treatment H 11.3 stopped in week 10)

<u>Height of leaves, height of flowers and number of buds and flowers:</u> Leaf height was not influenced by the different lighting treatments, although there was a significant difference in flower height. The flowers of plants from forcing week 01 with supplementary lighting were 5 to 7cm higher compared to plants in other glasshouse compartments. As a result of more vernalisation, the flowers were borne higher over the leaves. There were no significant differences in the amount of buds and flowers, generally around 2 to 3. More vernalisation could possibly produce more flowers and buds. (From the previous trial, the comparable *Ajuga reptans* 'Rosea' had more buds because of a more vernalisation during the storage treatment).

<u>General value:</u> Plants with supplementary light were barely marketable (scores of 5 to 6) because of the long stem shoots and low flower count per plant. Plants

form forcing week 01 attained the best scores. Plants exposed to ambient daylight and photoperiodic light generally scored under 5.

Shelf life test: The shortest period of time was 21 days whilst the longest time was 31 days (average 27 days). *Ajuga reptans* 'Braun Hertz' is suitable for living room conditions.

Recommendation for *Ajuga reptans* 'Braun Hertz': Cuttings root in about three weeks. Potting should be completed by week 31 to make sure that one rosette can fill the pot and the plants are of sufficient size prior to vernalisation. A 9 or 10 cm pot size is adequate. Ajuga needs to be well fed, nutritional levels should be at the higher level of 500 to 700mg N per plant. The plants require a cooling period of about 9 weeks. This is important for flowering and flower height. Minimal cleaning is required prior to marketing. With higher forcing temperatures of 12°C and supplementary lighting, it is possible to sell the Ajuga at Valentine's Day. With ambient daylight and temperatures of 10°C-12°C flowering will commence in the middle of March.

***Ajuga reptans* 'Mini Mahagoni'**

Lovely blue, long lasting flowers and almost no stolons at the time of flowering makes this species an early spring favourite (Figure 12). *Ajuga reptans* 'Mini Mahagoni' performs well as a single plant and in arrangements. Plant performance was not as good this year as last, the main reasons were that the plants were not given sufficient fertiliser during the autumn period, and therefore the plants did not fill the 10 cm pot and there was insufficient vernalisation, giving rise to a low flower number. Flowering data was recorded when three open flowers were visible on a flower stem. The trial tested plants from different potting dates. Plants that were potted in week 34 (species number 5) performed better than plants that were potted in week 38 (species number 25).

Figure 12: week 04; Early spring display – blue with *Ajuga reptans* 'Mini Mahagoni'

Forcing treatment: All the plants from the earlier potting came into flower, but a percentage of plants from the later potting date did not (Figure 13 and 14). Older plants (species number 5) exposed to supplementary lighting and from forcing weeks 50 and 01 (H 11.1, H 11.2 and H 10.1) flowered after 34-36 days. Plants flowered in 3-4 weeks from forcing week 50 and in 5-6 weeks from forcing week 01, both before Valentine's Day. The glasshouse compartment with supplementary lighting and 9°C (H10.2) had a one week delay in flowering (weeks 6 to 7). Plants exposed to supplementary lighting flowered 4 weeks earlier than plants exposed to photoperiodic light and 5 weeks earlier than plants exposed to ambient daylight. In last year's trial this delay was just 2 weeks because the plants had received a better level of vernalisation. The storage treatment had a significant influence on the plants in the glasshouses exposed to photoperiodic and ambient daylight. Plants from polythene tunnel were 3 weeks earlier in flowering (weeks 7 to 8) than plants from frost-free glasshouse (weeks 10 to 11).

Plants from the later potting exposed to supplementary light flowered after 36 to 38 days. Plants exposed to 80 klxh (H11.2) had a delay of one week. Plants exposed to 9°C from forcing week 01 flowered with a half-week delay. Plants exposed to photoperiodic and ambient daylight were both later and flowered weeks 10 to 11.

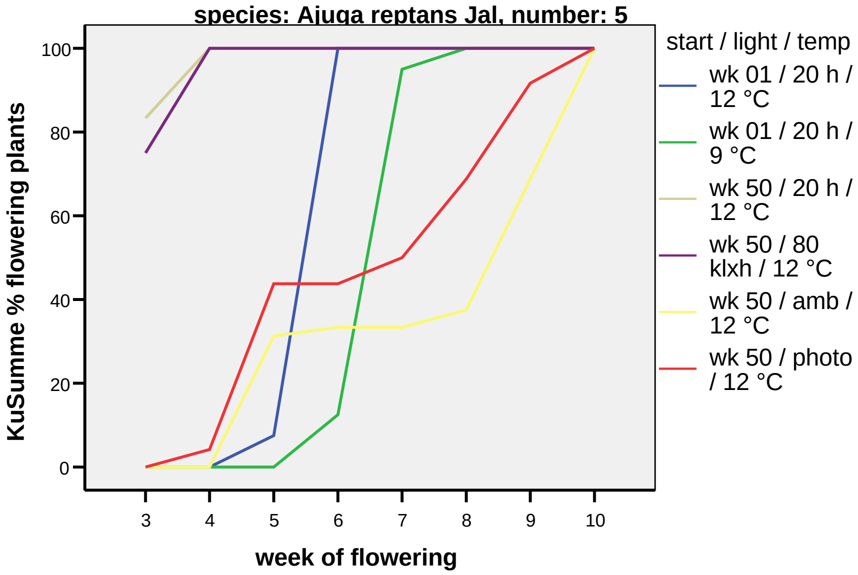

Figure 13: Percentage of flowering plants relative to the light treatments (photoperiodic lighting treatment H 11.3 stopped in week 10); *Ajuga reptans* 'Mini Mahagoni', potting week 34

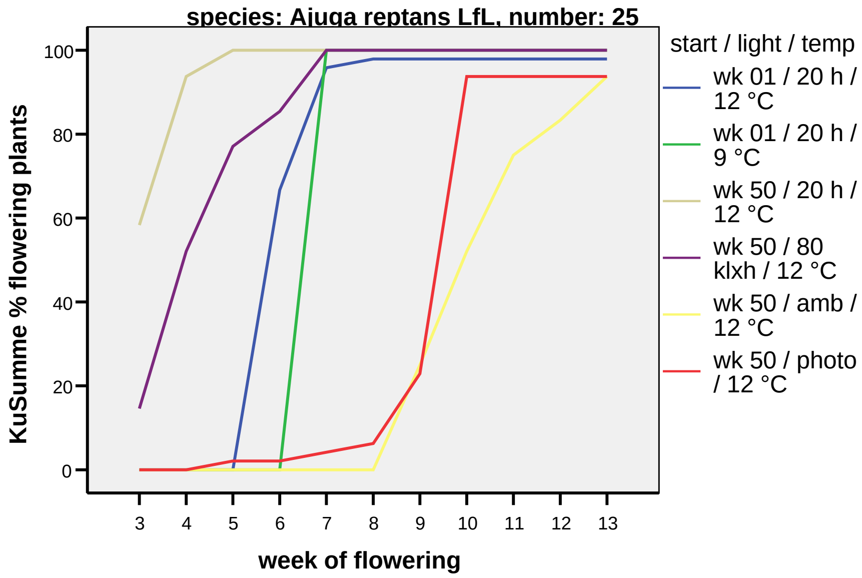

Figure 14: Percentage of flowering plants relative to the light treatments (photoperiodic lighting treatment H 11.3 stopped in week 10) *Ajuga reptans* 'Mini Mahgoni', potting week 38

Height of leaves, height of flowers and number of buds and flowers: Leaf height was not influenced by storage and lighting treatment. However, flower height was influenced by treatment, especially the start of forcing. All the plants with more vernalisation from forcing week 01 had flowers 6 to 7 cm higher (11 to 14 cm in length, Figure 15) than plants from forcing week 50 (5-7 cm in length). Plants from forcing week 01 and especially from the polythene tunnel and outdoors had more buds and flowers (12-14) compared to the other glasshouse compartments (7 to 8). All the plants exposed to supplementary light had on average more flowers and buds than plants exposed to photoperiodic and ambient daylight.

General value: All the plants exposed to supplementary light scored better (6 to 8) than plants exposed to photoperiodic and ambient daylight (4-5). The plants from the earlier potting date scored better than plants from the later potting date.

Shelf life test: The duration of shelf life was always 29 days. *Ajuga reptans* 'Mini Mahagoni' is ideally suited for living room conditions.

Recommendation for *Ajuga reptans* 'Mini Mahagoni': Cuttings root in about three weeks. Potting should be completed by week 33 to make sure that one rosette can fill the pot and the plants are of sufficient size prior to vernalisation. A 9cm pot size is adequate. Ajuga needs to be well fed, nutritional levels should be at the higher level of 500 to 700mg N per plant. A cooling period of about 9 weeks is required. This is important for flowering and flower height. Minimal cleaning is required prior to marketing. With forcing temperatures of 10°C to 12°C and supplementary light, it is possible to sell Ajuga at Valentine's Day.

Michigan State University work indicated that ajuga will only flower following a cooling treatment and that photoperiodic treatments do not regulate flowering (day-neutral). The trials showed that *Ajuga reptans* 'Bronze Beauty' flowered within two weeks at forcing temperatures of 20°C after a 15 week constant cooling period at 5°C (Fausey, B.; Padhye, S.; Runkle, E. and Cameron, A. 2005 and 2006). Ajuga has to be of a sufficient size prior to forcing otherwise flowering is inconsistent. The American work indicated that *Ajuga reptans* has to be vernalised for at least 6 weeks at 5°C.

Figure 15: week 7; *Ajuga reptans* 'Mini Mahagoni' from storage outdoor 2006/2007; start of forcing in week 01

***Aquilegia* F1 Spring Magic Series**

Aquilegia performed well during last year's trial. This year six different colours of *Aquilegia* F1 Spring Magic Series were tested as shown in the following images (Figures 16 - 21). The date of flowering was recorded when there was colour in one flower bud.

Figure 16: F 03 'Blue-white'

Figure 17: F 07 'Pink-white'

Figure 18: F 04 'Light red-yellow'

Figure 19: F 04 'Light red-white'

Figure 20: F 06 'Navy blue-white

Figure 21: F 08 'White'

Forcing treatment: All the aquilegia from the F1 series reacted in a similar way to forcing. Plants were of sufficient size prior to vernalisation and all the plants flowered. Plants exposed to supplementary light flowered 4 weeks earlier than plants exposed to photoperiodic light and 6 weeks earlier than plants exposed to ambient daylight. All the plants with supplementary light came into flower before Valentine's Day. Storage had a significant influence on plant performance. Plants from the frost-free glasshouse and under supplementary light at 12°C (H 11.1, H 10.1) flowered on average after 31 days compared to plants from the polythene tunnel that flowered after 37 days. The plants from forcing week 50 flowered in weeks 3 to 4 and plants from forcing week 01 flowered in weeks 5 to 6. The plants exposed to the 80 klxh light treatment (H11.2) had a half a week to one week delay in comparison to plants from the 20h 3000lx treatment (H11.1).

The same effect was also noted with the plants exposed to 20h-3000lx at 9°C treatment (H 10.2) which were delayed by almost one week in comparison to the 20h-3000lx at 12°C treatment (H10.1). This indicates that there is a correlation between temperature and light amounts.

All the plants exposed to ambient daylight came into flower, but the plants performed poorly, flower stems were short and the flowers were not held above the leaves because of the lack of vernalisation and the low light level (ambient daylight) until week 50. The photoperiodic light treatment compensated for the lack of vernalisation. Figure 22 shows the percentage flowering plants of *Aquilegia* 'F1 light red-yellow', this variety was typical of all the tested aquilegia from this series.

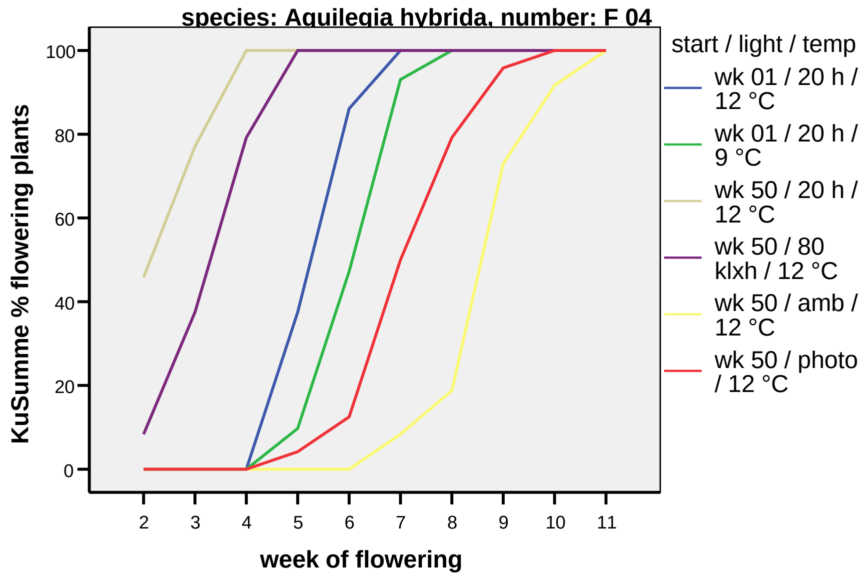

Figure 22: Percentage of flowering plants relative to the light treatments
Aquilegia 'F1 Spring Magic light red - yellow'

 

Figure 23 and Figure 24: *Aquilegia* 'F1 Spring Magic light red-yellow'; storage left: polythene tunnel, right: frost-free glasshouse, plants cleaned of old foliage

Figure 23 and 24 show the effect of the storage treatment on the amount of remaining foliage after storage.

<u>Height of leaves, height of flowers and number of buds and flowers:</u> Leaf height was influenced by both light and storage treatments. All the plants exposed to supplementary light were on average 5 to 6 cm taller than plants under ambient daylight and 3cm higher then plants under photoperiodic light. In most cases, plants from the frost-free glasshouse had taller leaves than plants from the polythene tunnel. Plants exposed to supplementary light or photoperiodic light from the frost-free glasshouse, were about 2 cm taller compared to plants from the polythene tunnel exposed to similar treatments. Even under ambient daylight, the plants from the frost-free glasshouse were 1 cm taller than plants from the polythene tunnel.

Plants from the frost-free glasshouse were better developed in terms of foliage. Half of the Aquilegia series (species number F03, F04 and F07) showed a significant difference between glasshouse compartments / treatments. Plants exposed to the 80 klxh (H11.2) treatment were around 2 cm shorter than the plants exposed to the supplementary light 20h 3000lx treatment (H11.1, H 10.1 and 10.2). The plants from forcing week 01 at 9°C (H 10.2) were the tallest, especially plants from the frost-free glasshouses (12 to 14 cm) compared to other treatments.

Flower height was influenced by light treatment and the start of forcing. Plants from forcing week 01 exposed to supplementary light had flower stems 4 to 7 cm longer than plants from forcing week 50 (possibly as a result of differences in vernalisation). Plants exposed to supplementary light had significantly taller flower stems than plants exposed to photoperiodic light. Plants exposed to ambient daylight generally had the shortest flower stems. In some cases the flowers were below the level of the foliage as a result of insufficient vernalisation. Under photoperiodic light, the flowers were on average just above the leaves when the first bud showed colour. One week after scoring under photoperiodic lighting, the flower stems had stretched above the foliage and the plants performed better but the first flower had already opened. This may cause problems during transport and marketing.

The shortest flower stems were noted on the *Aquilegia* 'F1 Blue-white' exposed to photoperiodic light. Most of the buds showing colour were still below the leaves. The photoperiodic lighting could not compensate for the lack of vernalisation this year in the case of this variety. The tallest flower stems developed on *Aquilegia* 'F1 Navy blue-white,' to a maximum of 29 cm in the case of plants exposed to supplementary light at 9°C from forcing week 01. In the case of this and the remaining varieties, the flower buds were borne above the leaves under the photoperiodic light treatment.

The number of buds and flowers was influenced by light treatment, start of forcing and in some cases by storage (Figures 25 and 26). Most varieties had more buds and flowers from forcing week 01 when exposed to supplementary light than plants from forcing week 50 exposed to supplementary light. The plants had in most cases one flower and 2 to 4 buds. The most developed flowers were from *Aquilegia* 'F1 light red-yellow' (F05) and *Aquilegia* 'F1 Pink-white'. Plants exposed to ambient daylight often had just the one flower. Plants exposed to photoperiodic light developed one flower and 1 to 2 buds. *Aquilegia* 'F1 light red-yellow' and 'F1 Navy blue-white' developed different numbers of flowers and buds in response to different storage treatments. Plants from the frost-free glasshouses developed 1 to 2 flowers more than plants from the polythene tunnel and outdoors. The plants from outdoors also had significantly less flowers and buds compared to plants from the frost-free glasshouse that were exposed to supplementary light. The cooler outdoor conditions set the back plant development.

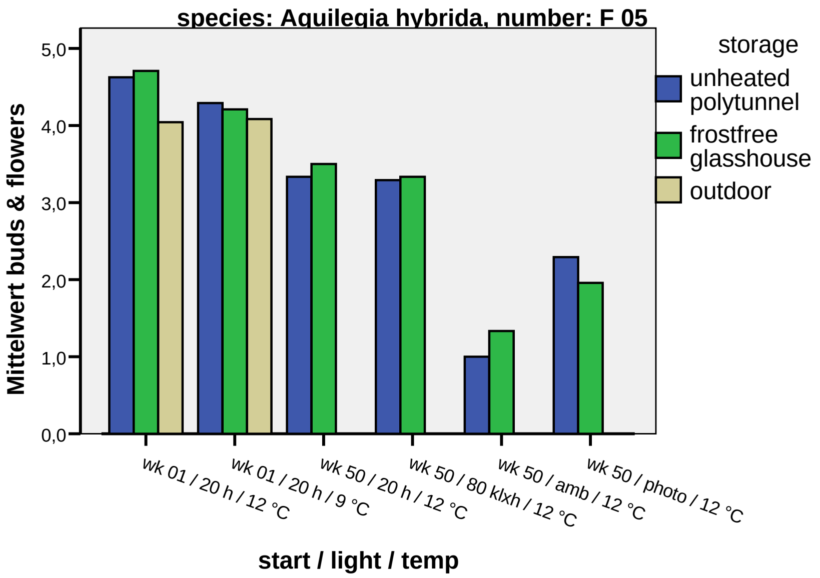

Figure 25: Bar chart of the average number of buds and flowers; *Aquilegia* 'F1 Spring Magic light red-yellow'

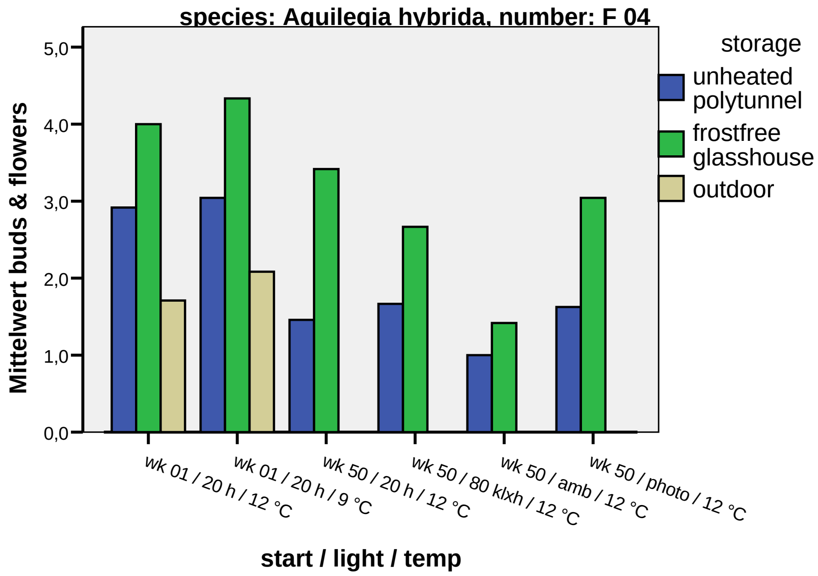

Figure 26: Bar chart of the average of number buds and flowers; *Aquilegia* 'F1 Spring Magic light red-yellow'

General value: Plants exposed to supplementary light scored significantly higher (6 to 7) than plants exposed to photoperiodic light (5 to 6) and ambient daylight (3 to 4). *Aquilegia* 'F1 Blue-white' scored lower (4-5) because the buds showing colour were often under the leaves. Plants performed significantly better from the frost-free glasshouse than plants from the polythene tunnel or outdoors. The plants developed more foliage.

Shelf life test: The tested Aquilegia had a longer shelf life in this year trial than last year because the plants developed more buds. The shortest time in shelf life was 15 days and the longest 26 days. This makes the *Aquilegia* F1 series suitable for living room conditions.

Recommendation for *Aquilegia* F1 Series: Potting should be completed by week 36 (better if earlier) to obtain plants of sufficient size prior to vernalisation. The vernalisation is necessary to ensure sufficient flower stem height. Plants should be ideally kept in a frost-free glasshouse, as cold as possible, for about 9 weeks. Plants that were sufficiently vernalised were able to produce quality plants under photoperiodic light for Valentine's Day. Cleaning the plants prior to marketing can be labour intensive. Plants can be successful under ambient daylight too but they flower at a later date, the beginning of March onwards. Growing Aquilegia successfully depends on obtaining sufficient plant size prior to forcing, correct vernalisation and appropriate temperatures and light levels.

Michigan State University work indicated that aquilegia will only flower following a cooling treatment and photoperiod does not control flowering (day-neutral). The tested .Aquilegia, *A. flabellata* 'Cameo' needed at least 6 weeks to create a plant of sufficient size prior to forcing (Fausey, B.; Padhye, S.; Runkle, E. and Cameron, A. 2005 and 2006). 6-9 weeks of vernalisation at a constant 5°C were recommended and the plants needed 4 weeks to flower at 20°C.

***Calceolaria biflora* 'Goldcap'**

This variety produces a number of yellow flowers on thin flower stems over a dark green rosette of leaves (Figure 27). This species was included in the trial for the first time last year and attracted attention. *Calceolaria biflora* 'Goldcap' performed well as a single plant and in arrangements. *Calceolaria biflora* requires long-day to flower. Extrapolating from other calceolaria species the critical day length seems to be 14 hours. It is not known whether calceolaria has a vernalisation requirement and how long this has to be. The date of flowering was recorded when one open flower was noted on a plant.

Figure 27: week 06; *Calceolaria biflora* 'Goldcap'; supplementary light

Forcing treatment: All the plants exposed to supplementary light came into flower (Figure 28). Almost all the plants exposed to photoperiodic light flowered, only a couple of plants had no buds at the end of scoring. There was no flowering under ambient daylight until week 14. The storage treatments had no significant influence.

Only the plants from forcing week 50, exposed to supplementary light and from the polythene tunnel were earlier than plants from the frost-free glasshouse (by a week). Plants from forcing week 50 exposed to supplementary light 20h-3000lx (H11.1) were one week earlier than the plants exposed to the 80 klxh treatment (H11.2). Plants exposed to supplementary light at 12°C (H10.1) were one week earlier than plants exposed to supplementary light and 9°C. Plants exposed to supplementary light and 12°C flowered in average after 50 days. The plants in the other light and temperature combinations (H11.2 and 10.2) flowered after 57 days. Plants from forcing week 50 exposed to supplementary light flowered in weeks 4 to 5 and plants from forcing week 01 in weeks 7 to 8. The plants flowered earlier than last year. The reasons for this earlier flowering were that the plants received their light treatment one week earlier and received a higher sum of light and temperatures until Valentine's Day compared to last year. Plants exposed to photoperiodic light flowered on average after 72 days in weeks 8 to 9. The plants from forcing week 01 flowered at about the same time during weeks 7 to 9.

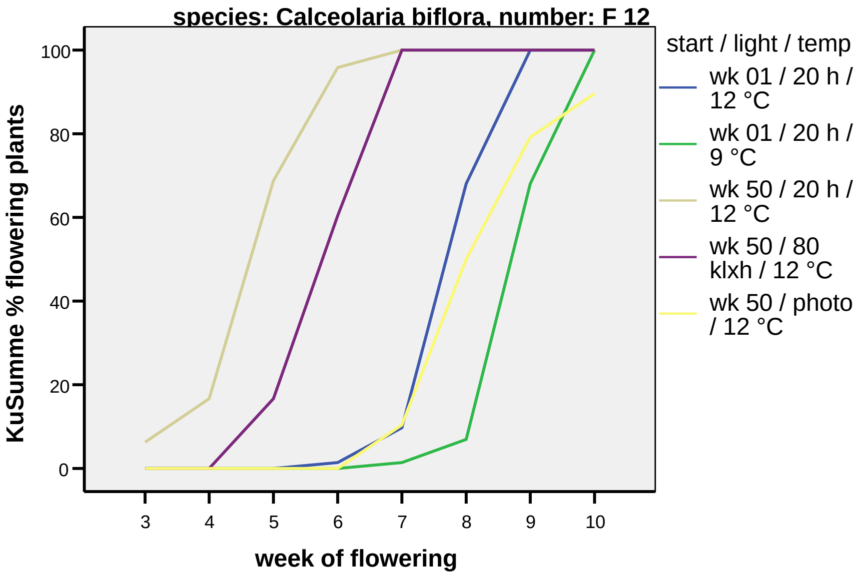

Figure 28: Percentage of flowering plants relative to the light treatments
(photoperiodic lighting treatment H 11.3 stopped in week 10)

Height of leaves, height of flowers and number of buds and flowers: Leaf height was influenced by storage treatment, plants from forcing week 50 and from the frost-free glasshouse were 2 cm higher than plants from the polythene tunnel. Most plants were on average 7 to 8 cm tall. The height of flowers was not influenced by lighting or storage treatment. Flowers were on average 17 to 18 cm tall. The number of buds was influenced by the lighting treatment and the start of forcing. Plants from forcing week 01 exposed to supplementary light developed 2 to 3 buds more (14 to 16) than plants from forcing week 50 (11-12). The effect could be the result of plants having received a longer cooling period. Plants under the photoperiodic light treatment developed significant fewer flowers and buds (9 to 10).

General value: The storage treatment had no influence on the general value. Plants under photoperiodic light scored significantly lower (about 6) compared to the other treatments (7 to 8) as a result of a more open plant habit.

Shelf life test: The shortest time in shelf life was 21 days and the longest 31 days. This makes Calceolaria suitable for living room conditions.

Recommendation for *Calceolaria biflora* 'Goldcap': Potting should be completed by week 35. A pot size of 10cm is adequate. Pre-forcing storage can take place in frost-free glasshouse or polythene tunnel from weeks 40 to 50. Calceolaria is an obligate long day plant. A moderate level of cleaning is required prior to marketing. Under supplementary light (20 hours) at 12°C from a week 50 forcing week *Calceolaria biflora* 'Goldcap' will flower for Valentine's Day.

***Erysimum perovskianum* 'Goldrush'**
This species was included in the trial for the first time last year under supplementary light and attracted attention as an early spring pot plant. The flowers are bright yellow in colour (Figure 29) and have a strong scent. Not all plants came into flower during the trial this year however, the reasons for which are not clear. Some plants came into flower prior to forcing and the flowers were

removed in week 45, but most plants were able to produce further flowers. The vernalisation treatment appears to influence the success of flowering. All the plants from forcing week 01 flowered (except a couple of plants from the frost-free glasshouse) because of the longer vernalisation period. All the plants from forcing week 50 stored in the polythene tunnel flowered, some plants from frost-free glasshouse did not. The date of flowering was recorded when three open flowers were present on a flowering stem.

Figure 29: week 03; *Erysimum perovskianum* 'Goldrush' ; supplementary light

Forcing treatment: Plants exposed to supplementary light at 12°C flowered on average after 38 days. Plants from forcing week 50 flowered in weeks 3 to 4 and plants from forcing week 01 flowered in weeks 6 to 7 just before Valentine's Day (Figure 30). Plants from forcing week 01 exposed to supplementary light at 9°C flowered almost one week later than those grown at 12°C. Plants exposed to supplementary light were 2 weeks earlier than plants exposed to photoperiodic and 4 weeks earlier than plants exposed to ambient daylight. Flowering occurred over a long period. There were some early flowers under ambient daylight conditions (erysimum is a day-neutral plant). The storage treatment was significant under the photoperiodic light and ambient daylight treatments. Plants from the polythene tunnel were 1 to 2 weeks earlier than plants from frost-free glasshouse.

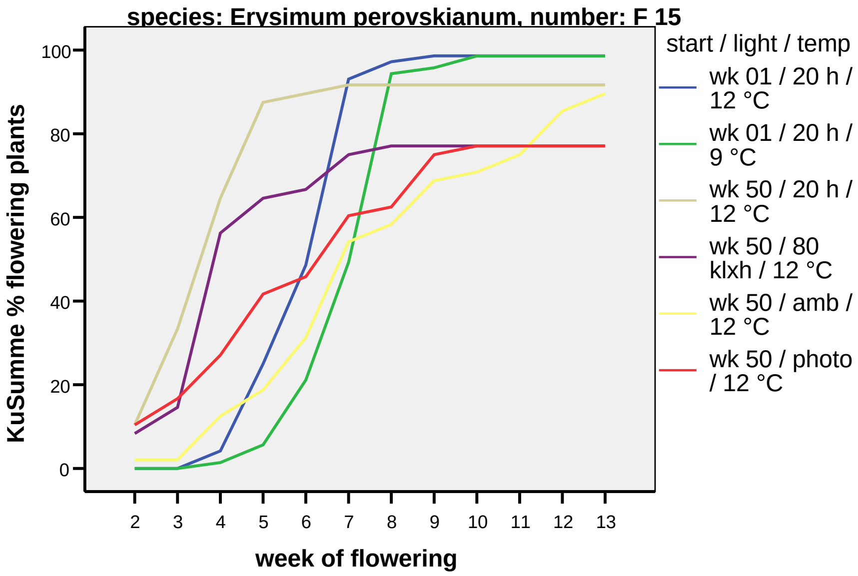

Figure 30: Percentage of flowering plants relative to the light treatments
(photoperiodic lighting treatment H 11.3 stopped in week 10)

Height of leaves, height of flowers and number of buds and flowers: Leaf height was not influenced by either storage or lighting treatment but flower height was. Plants from forcing week 01 from outdoors had flowers 4 cm taller (17 to 19 cm in height) than plants from forcing week 50 (14cm). The reason may be that the plants received a longer cooling period. Plants exposed to photoperiodic and ambient daylight had shorter flower stems (10 to 11cm) than plants exposed to supplementary light. In half of the glasshouse compartments, the influence of storage was significant. Plants from the polythene tunnel and outdoors were taller relative to plants from the frost-free glasshouse. The number of buds was influenced by storage and the start of forcing. Most plants from forcing week 50 from the polythene tunnel had 2 buds more than plants from the frost-free glasshouse. Plants from forcing week 01 developed 2 to 3 buds more (7 to 9) than plants from forcing week 50 (polythene tunnel; 5 to 7).

General value: Plants with the best scores were those from forcing week 01 which were exposed to supplementary light at 12°C (6 to 7). Plants from the ambient daylight and photoperiodic light treatments had the lowest scores (4 to 6). The plants from the polythene tunnel scored better marks than plants from frost-free glasshouse. The plants could not fill the 10 cm pot.

Shelf life test: The shortest time in shelf life was 19 days and the longest 39 days. Shelf life was determined by the number of buds per plant that were present at the beginning of shelf life. *Erysimum perovskianum* 'Goldrush' is suitable for living room conditions.

Recommendation for *Erysimum perovskianum* 'Goldrush': Potting should be completed by week 36. A 9 cm pot is adequate. Pre-forcing storage can take place in a frost-free glasshouse or polythene tunnel from weeks 40 to 50. Adequate levels of vernalisation are important. *Erysimum perovskianum* 'Goldrush' is a day-neutral and that requires a cooling treatment. Minimal plant cleaning is required prior to marketing. Supplementary light forces plants into flower and is able to compensate for lack any of vernalisation. Plants flower from Valentine's Day even under ambient daylight conditions.

***Iberis sempervirens* 'Snowflake'**
The bright white flowers of iberis are attractive in early spring arrangements. This year the iberis did not flower as well as in previous years (Figure 31). The plants were of insufficient size prior to vernalisation. Not all plants came into flower. The date of flowering was recorded when there were 3 to 4 open flowers per plant.

Figure 31: week 08; *Iberis sempervirens* 'Snowflake'; ambient daylight; polythene tunnel

Forcing treatment: All plants exposed to supplementary light flowered on average after 36 days. Plants from forcing week 50 flowered in weeks 3 to 4 and plants from forcing week 01 flowered in weeks 5 to 7, both before Valentine's Day (Figure 32). Plants exposed to supplementary lighting treatments were about 5 weeks earlier into flower than plants exposed to photoperiodic light and 6 weeks earlier than plants exposed to ambient daylight. This delay was a result of less vernalisation during storage. In former trials, it was possible to initiate flowering for Valentine's Day under ambient daylight. This year the supplementary light compensated for the lack of vernalisation.

The influence of storage was significant under photoperiodic light. Plants from the polythene tunnel from forcing week 50 flowered earlier (week 7) compared to plants from the frost-free glasshouse (week 9).

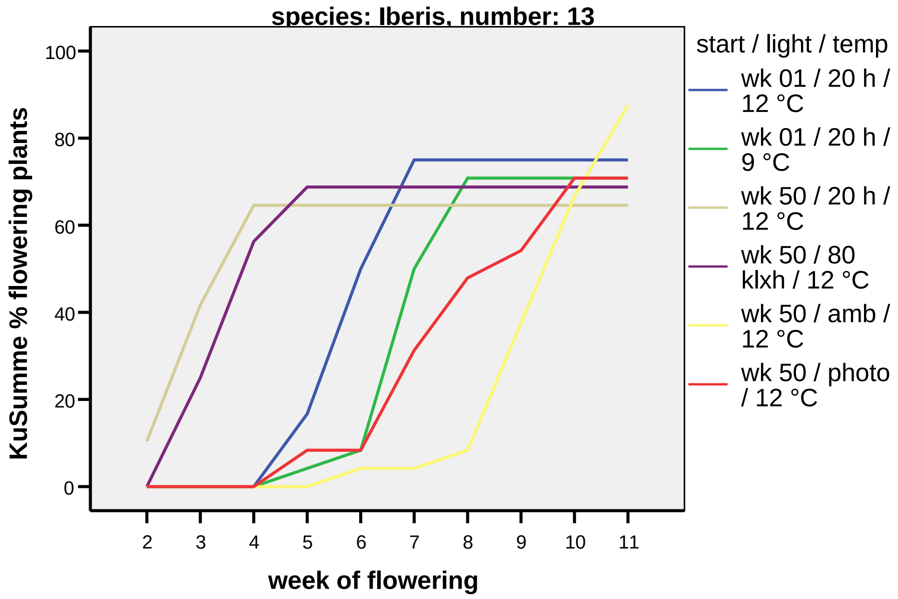

Figure 32: Percentage of flowering plants relative to the light treatments
(photoperiodic lighting treatment H 11.3 stopped in week 10)

<u>Height of leaves, height of flowers and number of buds and flowers:</u> Leaf height was measured to where the plant branched. This was generally around 3 to 5 cm. There was no significant influence of either lighting or storage treatment on leaf height. The height of flowers was significantly influenced by light treatment, plants exposed to supplementary light had flower stems 15 to 17 cm tall compared to photoperiodic light (10 cm high) and ambient daylight (8 cm high). The number of buds and flowers was not generally influenced by either lighting or storage treatment. Only plants from forcing week 01 from outdoors were influenced by storage. Plants developed 2 buds more than all other treatments (a vernalisation effect).

<u>General value:</u> The plants were unable to fill the 10 cm pot, the general value was low as a result. Plants under photoperiodic light, ambient daylight and plants from forcing week 01 scored better than plants from forcing week 50 exposed to supplementary light. The best scores achieved were for plants from outdoors as they had more developed flowers per plant (average 4.8).

<u>Shelf life test:</u> The shortest time in shelf life was 11 days and the longest 14 days (average 13 days). In previous trials, the shelf life was 17 days because of more buds per plant. *Iberis sempervirens* ‘Snowflake’ is suitable for living room conditions.

<u>Recommendation for *Iberis sempervirens* ‘Snowflake’:</u> Potting should be completed by week 32. An 8-9 cm pot size is adequate with one plant per pot. Plants should be trimmed after 4 weeks to increase branching. Plants should be of a sufficient size prior to vernalisation, with probably more than 40 leaves before cooling begins. Pre-forcing storage can take place in a frost-free glasshouse or polythene tunnel from weeks 40 to 50. It is important that plants receive enough vernalisation. There is very little need to clean the plants prior to marketing. *Iberis sempervirens* ‘Snowflake’ is a day-neutral plant and only flowers following vernalisation. Supplementary light forces flowering and is able to compensate for any lack of vernalisation. Plants flower for Valentine’s Day even under ambient daylight conditions.

Michigan State University trials indicate that *Iberis sempervirens* 'Snowflake' and 'Alexander's White' and other varieties only flower following a cooling treatment and that photoperiod does not influence flowering (day-neutral) (Fausey, B.; Padhye, S.; Runkle, E. and Cameron, A. 2005 and 2006). Plant size prior to vernalisation is important. At least 8 weeks of vernalization at a constant 5°C are recommended, and the tested plants flowered after 2 to 3 weeks at 20°C forcing temperatures.

***Lindernia* 'Grandiflora'**

Small dark blue and white flowers are borne amongst tiny green heart-shaped leaves on this spreading plant (Figure 33). The creeping foliage is able to cover the pot surface quickly. The species is a native of Florida native and has to be protected against frost. It performed very well in the shelf life test. All the plants came into flower well before Valentine's Day except plants from the polythene tunnel from forcing week 01. Plants received a little frost in the polythene tunnel and had to re-grow again before flowering. The date of flowering was recorded when there were 3 to 4 open flowers per plant.

Figure 33: week 06, *Lindernia* 'Grandiflora', supplementary light

Forcing treatment: All the plants exposed to supplementary light flowered with 3 to 4 open flowers after 23 days except plants from the polythene tunnel from forcing week 01, these flowered after 40 to 60 days. Plants exposed to ambient daylight flowered after 40 days. Plants from forcing week 50 exposed to supplementary and photoperiodic light flowered in week 1 (Figure 34). Plants exposed to ambient daylight and plants from forcing week 01 from the frost-free glasshouse flowered in week 4 compared to plants from the polythene tunnel (week 9 and week 7).

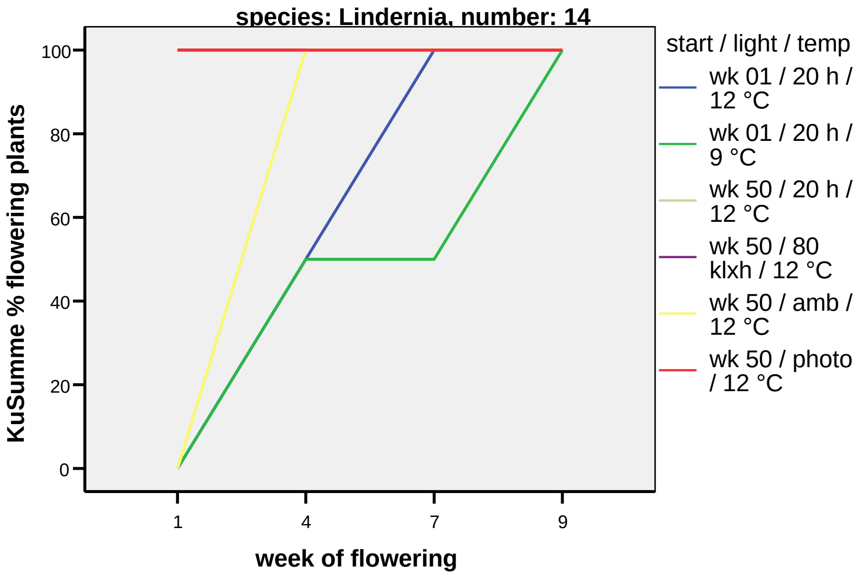

Figure 34: Percentage of flowering plants relative to the light treatments
(photoperiodic lighting treatment H 11.3 stopped in week 10)

Height of leaves, height of flowers and number of buds and flowers: As the flowers occurred at the end of foliage the measured height for leaves and flowers was the same. Plants exposed to supplementary light from forcing week 50 were longer (11-12 cm) compared to plants exposed to supplementary light from forcing week 01 (7- 9 cm) and plants exposed to photoperiodic light (9-10 cm).

General value: The plants were unable to fill the 10 cm pot. Plants were not sufficiently branched, as a result the general value was low. Plants from the frost-free glasshouse scored best (average 4.8).

Shelf life test: The shortest time in shelf life was 38 days and the longest 47 days (average 43 days). All the flower buds opened up and the plants were covered with flowers. Lindernia performs better in higher temperatures and is suitable for living room conditions.

Recommendation for *Lindernia* 'Grandiflora': Cuttings root in about three weeks. Potting should occur prior to week 31 to allow trimming so that plants branch better and fill the 9 cm pots. Alternatively, 2 to 3 cuttings can be used in a 10 to 11 cm pot. Lindernia appears to be a plant, which flowers regardless of cooling and photoperiod treatment. There is more dependence on temperature with this species. There is a minimal need for cleaning with this species prior to marketing. At forcing temperatures of 12°C (after a time of frost-free storage), flowers appear after 3 weeks.

***Serissa foetida* 'Pink Mystic'**
This species is a small compact shrub and performs like (and is sold as) a bonsai plant ready for selling at Valentine's Day (Figures 35 and 36). The small leaves are green and white and the flowers are small pink and white stars. All the plants came into flower by the end of the trial except those plants from the polythene tunnel from forcing week 01 at 9°C. Serissa is not hardy and prefers warmer temperatures. The date of flowering was recorded when one flower was open per pot.


Figure 35 and Figure 36: week 05 left and week 08 right; *Serissa foetida* 'Pink Mystic'; supplementary light

Forcing treatment: Although the majority of the plants flowered, the flowering period was over a long time. The storage treatments had a significant influence on flowering, plants exposed to supplementary light and photoperiodic light from the frost-free glasshouse flowered about 1 week earlier than plants from polythene tunnel. Plants exposed to ambient daylight reacted the opposite way, in that plants were 1 week earlier from the polythene tunnel than plants from the frost-free glasshouse. Plants from forcing week 50 exposed to supplementary light flowered for Valentine's Day in weeks 6 to 7 (Figure 37). Plants exposed to photoperiodic and ambient daylight flowered in weeks 6 to 8 and 6 to 9 respectively. Plants from forcing 01 exposed to supplementary light flowered in week 9 to 10. Only plants from the polythene tunnel exposed to supplementary light at 9°C did not flower until the end of scoring.

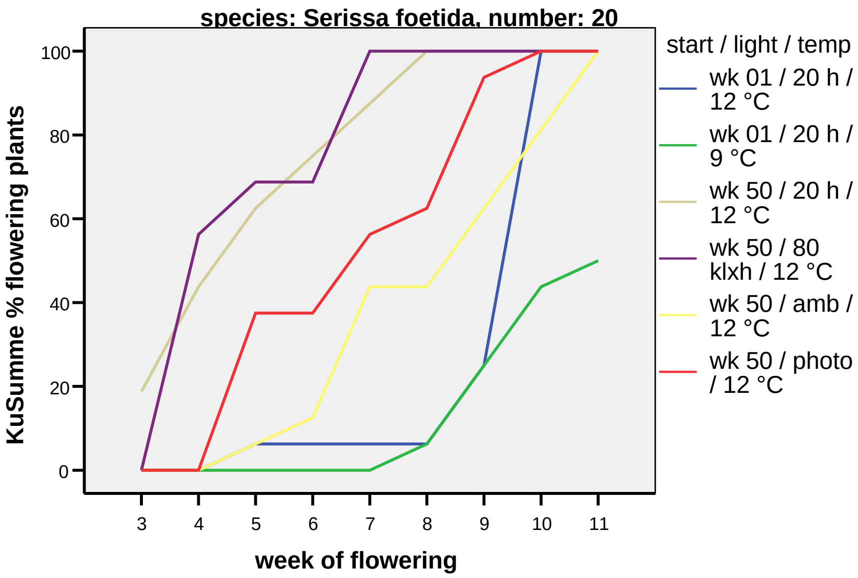

Figure 37: Percentage of flowering plants relative to the light treatments
(photoperiodic lighting treatment H 11.3 stopped in week 10)

Height of leaves, height of flowers: Leaf and flower height were not influenced by lighting or storage treatment.

General value: The plants were unable to fill the 10 cm pot and therefore the average score was about 6. With a suitable pot size and the knowledge that all buds would open up in shelf life then serissa could have scored much better.

Shelf life test: The shortest time in shelf life was 19 days and the longest 24 days (average 22 days). Serissa prefers the higher temperatures and is suitable for living room conditions.

Recommendation for *Serissa foetida* 'Pink Mystic': Cuttings root in about three weeks. Potting should be completed by week 31 in a 9 cm pot. Plants develop branches without trimming. There is no need to clean the plants prior to marketing. Flowering is possible before Valentine's Day at 12°C and with a forcing week beginning week 50.

***Erinus alpinus* 'Dr. Hähnle'**

This pink flowering plant is actually a recommendable early spring pot plant (Pillnitz trial 2002/2003; Figure 40). However, this year there was insufficient flower to allow an evaluation. The reasons for this were the late potting date and the lack of vernalisation until week 50 (Figures 38 and 39). Plants from forcing week 01 received three weeks more vernalisation until forcing and the flower stems were taller under supplementary light. However, the number of flowers per plant was still too low.

Figure 38 and Figure 39: week 09; *Erinus alpinus* 'Dr. Hähnle'; supplementary light 12°C left: forcing week 50, right: forcing week 01 and plants from outdoor

Figure 40: 2003; week 10; *Erinus alpinus* 'Dr. Hähnle'; supplementary light at 10°C

***Barbarea rupicola* 'Sunnyola'**

This species failed this year because the general value scored was too low. The yellow flowers were not tall enough to be displayed above the foliage. The vernalisation period was not long enough during the mild autumn and winter even up until week 01 when the second forcing treatment started. There was a sign that flowers were taller on plants from forcing 01 exposed to supplementary light than on plants from forcing week 50. There is a need for further work on vernalisation with this species.

3.2 Record by species (with and without growth regulator treatments)

As part of the trial the response of 13 species were tested against two growth regulator treatments. Both Lychnis varieties failed to flower as a result of insufficient vernalisation and were not recorded. Table 9 gives a summary of the effects of the growth regulator treatments on the tested species. Further detail on each species (with and without growth regulators) is given in the following section.

Table 8: Reaction to Topflor and Chlormequat 720 by plant species

Number	Species / variety	Topflor	CCC 720
15	*Lithodora diffusa* 'Heavenly Blue'	++	+
24	*Phlox divaricata*	++	+
26	*Phlox divaricata* (propagation material Pillnitz)	++	+
F01	*Anacyclus pyrethrum var. depressus* 'Silberkissen'	+	+
F02	*Androsace septentrionalis* 'Star Dust'	+	0
F09	*Aquilegia vulgaris* 'Winky Double White-White'	+	+
F13	*Erigeron karvinskianus* 'Stallone'	++	+
F16	*Geum coccineum* 'Cooky'	0	+
F18	*Horminum pyrenaicum*	0	+
F19	*Lychnis alpina*	lack of vernalisation no flowers	
F20	*Lychnis alpina* 'Snow Furry'		
F21	*Papaver miyabeanum* 'Pacino'	+	+
F22	*Papaver nudicaule* 'Garden dwarf'	0	0
F23	*Silene pendula* 'Lausitz'	+	++

Key - 0 = no reaction, + = less inhibition effect, ++ = strong inhibition effect

***Anacyclus pyrethrum var. depressus* 'Silberkissen'**
This species performed very well again in this year's trial. The flower is coloured white on the upper side and purple on the under side (Figure 41). All of the plants came into flower. The date of flowering was recorded when there were three open flowers per plant.

Figure 41: week 07; *Anacyclus pyrethrum var. depressus* 'Silberkissen'; supplementary light

Anacyclus pyrethrum var. depressus 'Silberkissen' and no growth regulator treatment

Forcing treatment: The supplementary light treatment reduced the time to flower relative to the photoperiodic and ambient daylight treatments. Storage had no influence on flowering. Plants from forcing week 01 at 12°C came into flower the fastest (an average of 49 days), compared with plants from forcing week 01 at 9°C and forcing week 50 (an average of 55 days). Plants exposed to photoperiodic light were 2 weeks earlier than plants exposed to ambient daylight. Flowering was earlier than expected this year because the temperature and light sums were higher up to Valentine's Day than in previous years. It is not clear how much of an effect vernalisation has on Anacyclus. However there appears to be a correlation between temperatures and light level. Plants exposed to supplementary light from forcing week 50 at 12°C flowered before Valentine's Day in weeks 5 to 6 (Figure 42).

Height of leaves, height of flowers and number of buds and flowers: As the flowers were borne at the end of stems the measured height for leaves and flowers were approximately the same. All plants were about the same height at around 14 cm. There were two exceptions, the photoperiodic light treatment stretched the plants more than other lighting treatments (to 22 cm in height) and plants from forcing week 01 and from outdoors were about 17 cm in height. The number of buds and flowers was not influenced by lighting treatment except plants in glasshouse compartment H 11.2 (20-80klxh) which had on average 2 to 3 buds more than the others.

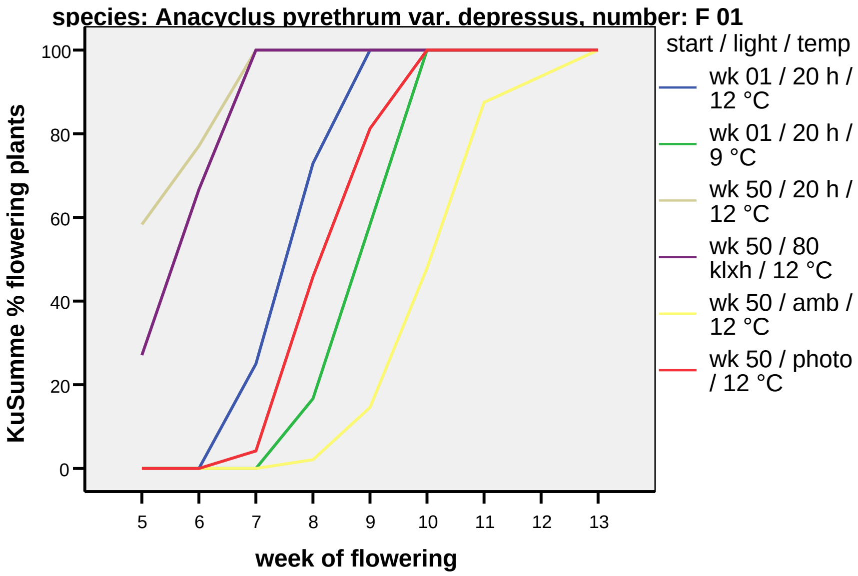

Figure 42: Percentage of flowering plants relative to the light treatments
(photoperiodic lighting treatment H 11.3 stopped in week 10)

The storage treatments had an influence on the plants exposed to ambient daylight and photoperiodic light. Plants from the polythene tunnel had on average 2 buds more than plants from the frost-free glasshouse, it is difficult to say whether this difference was related to vernalisation. Plants from forcing week 01 and from outdoors developed less buds because the low temperatures were disadvantageous for development.

General value: Plants exposed to supplementary light form forcing week 50 and supplementary light scored the best (6-7). Plants exposed to photoperiodic light and plants from forcing week 01 from outdoors scored the lowest because of the long stretched foliage.

Shelf life test: The shortest time in shelf life was 14 days and the longest 26 days (average 22 days). Anacyclus is suitable for living room conditions.

Anacyclus pyrethrum var. depressus 'Silberkissen' and growth regulator treatments

Forcing treatment: no influence.

Height of leaves, height of flowers and number of buds and flowers: Topflor and CCC 720 had more influence at the most frequent (lower) application rates under the supplementary light treatment. Plants were on average 2 to 3 cm shorter than untreated plants and plants treated with the higher application rates. Plants exposed to ambient daylight were more influenced by the higher application rates and were 2 cm shorter then untreated plants. Plants exposed to photoperiodic light were 5 cm shorter (17 cm) in response to all the growth regulators treatments than untreated plants (22 cm). There was no influence on flower and bud number.

General value: no influence

Recommendation for *Anacyclus pyrethrum var. depressus* 'Silberkissen': Potting should be completed by week 36 to allow adequate plant development, although the necessity of vernalisation during storage is not clear. However, plants exposed to supplementary light from forcing week 50 at 12°C will flower before Valentine's Day. There is a moderate need to clean the plants prior to marketing. Photoperiodic and ambient daylight treatments will bring the plants into flower later. Growth regulator treatments can be useful in combination with photoperiodic light.

***Androsace septentrionalis* 'Star Dust'**

This unusual species has short rosettes of leaves and spikes of small white flowers (Figure 43). Androsace performs well, especially in arrangements. All the plants came into flower, but there was an appearance of 'buckled' flower stems with some plants, the reason for this is not clear. The date of flowering was recorded when three open flowers were present on a flower stem.

Figure 43: week 03; *Androsace septentrionalis* 'Star Dust'; supplementary light

Androsace septentrionalis 'Star Dust' and no growth regulator treatments

Forcing treatment: Plants exposed to supplementary light were 5 to 7 weeks earlier than plants exposed to photoperiodic and ambient daylight. Plants from forcing week 01 at 12°C (supplementary light) and from outdoors were the quickest into flower (23 days), one week faster than plants from forcing week 50 (30 days). Plants from the polythene tunnel were always 1 to 2 weeks earlier than plants from the frost-free glasshouse. A storage effect was noted under ambient daylight and photoperiodic light. Plants from the polythene tunnel were 2 to 3 weeks earlier than plants from the frost-free glasshouse. Plants from forcing week 50 and week 01 flowered before Valentine's Day (Figure 44). Plants exposed to the photoperiodic and ambient daylight treatments flowered over a longer period of time and were later into flower this year because of a reduced vernalisation period. That indicates a positive need for vernalisation.

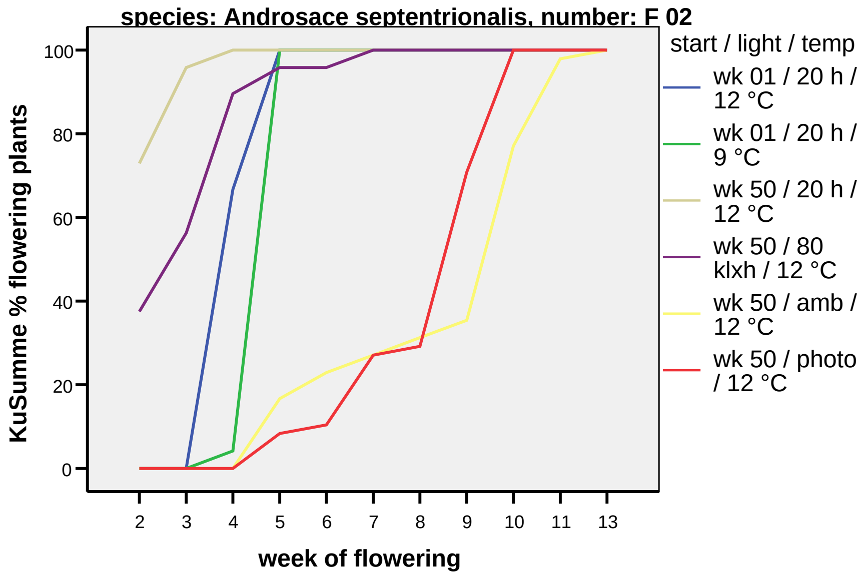

Figure 44: Percentage of flowering plants relative to the light treatments
(photoperiodic lighting treatment H 11.3 stopped in week 10)

Height of leaves, height of flowers and number of buds and flowers: There was no real influence on leaf height but flower height was influenced by lighting and storage treatment. Plants from forcing week 01 and from outdoors had flower stems 3 to 4 cm taller (23 cm on average) than plants from forcing week 50 (19 cm on average) and 4 to 5 cm taller than plants exposed to photoperiodic and ambient daylight (17 cm on average). Plants from the polythene tunnel had taller flower stems than plants from the frost-free glasshouse. The more vernalisation the plant experienced the more the flower stems extended above the leaves. This year one single plant was potted per pot and the rosette produced was sufficient to fill the 10 cm pot during autumn. However, one rosette only tends to develop one main flower in the middle of the plant and flower counts were lower this year as a result.

General value: Plants exposed to supplementary light scored better (6 to 7) than plants exposed to photoperiodic light and ambient daylight (5 to 6). These scores are lower than in previous years because of the one rosette with its single flower stem. As mentioned, due to insufficient vernalisation flower stems were also shorter under photoperiodic light and ambient daylight treatments. The storage treatment had no influence on general value.

Shelf life test: The shortest time in shelf life was 23 days and the longest 23 days (average 23 days). *Androsace septentrionalis* 'Star Dust' is suitable for living room conditions.

Androsace septentrionalis 'Star Dust' and growth regulator treatments
Forcing treatment: Plants treated with Topflor (2 times and 4 times) had almost a one week delay in flowering.

Height of leaves, height of flowers and number of buds and flowers: There was no influence on leaf height. Plants treated with Topflor had flower stems 2cm shorter than untreated plants (Figure 45). The influence of CCC 720 was not significant.

Figure 45: week 05; *Androsace septentrionalis* 'Star Dust' from left to right: untreated, 2x Topflor, 4x Topflor

General value: no influence.

Recommendation for *Androsace septentrionalis* 'Star Dust': Sowing should occur around weeks 29 to 31 and potting weeks 32 to 33 to allow sufficient foliage growth prior to storage. Three plants (seedlings) per pot perform better in terms flowering at Valentine's Day. A 9 to 10 cm pot size is adequate. Feeding using a liquid fertiliser is generally necessary, although applications of nitrogen should not be above 200mg N per plant. If vernalisation is sufficient during storage, plants are able to flower at Valentine's Day even under ambient daylight (forcing week 50 at 12°C). Flowering will be earlier and more uniform under supplementary light. Supplementary light is able to compensate for any lack of vernalisation. There is minimal need for cleaning prior to marketing. The growth regulator Topflor was effective at controlling flower height but flowering was delayed as a result.

***Aquilegia vulgaris* 'Winky Double White-White'**
Only one flower colour (white) was tested in the trial this year. This species has double flowers (Figures 46 and 47) and is suitable as a background plant in spring arrangements. All the plants came into flower except three plants exposed to ambient daylight. Insufficient vernalisation limited flower stem elongation. The date of flowering was recorded when there was one open bud on a flower stem.


Figure 46 and Figure 47: week 05; *Aquilegia vulgaris* 'Winky Double White-White'; supplementary light, *Aquilegia vulgaris* 'Winky Double White-White' and no growth regulator treatments

***Aquilegia vulgaris* 'Winky Double White-White' and no growth regulator treatments**

<u>Forcing treatment:</u> Plants exposed to supplementary light were 4 to 5 weeks earlier into flower than plants exposed to photoperiodic light and 8 to 9 weeks earlier than plants exposed to ambient daylight. Plants from forcing week 50 exposed to 20h-3000lx lighting treatment were one week earlier than plants exposed to 80klxh. Plants from the frost-free glasshouse were one week earlier than plants from the polythene tunnel. Plants from forcing week 50 and supplementary light flowered in weeks 4 to 6 before Valentine's Day (Figure 48).

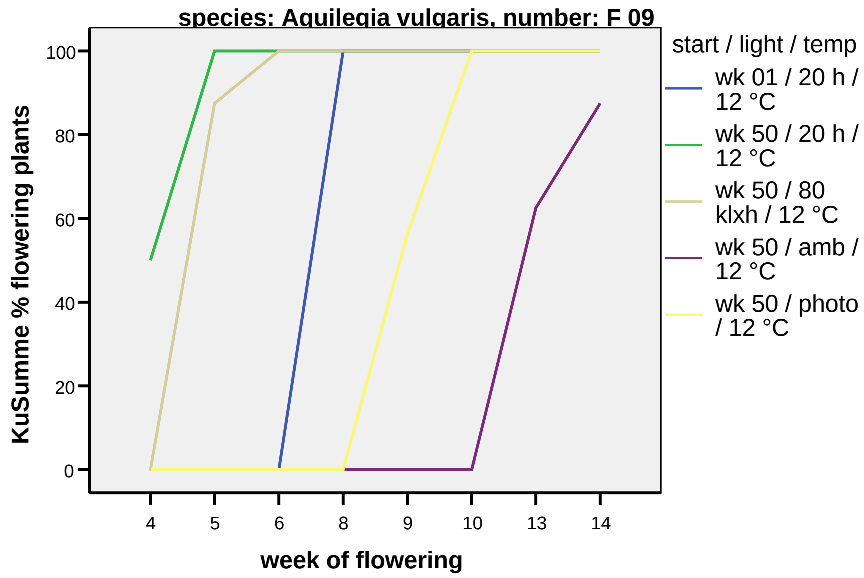

Figure 48: Percentage of flowering plants relative to the light treatments
(photoperiodic lighting treatment H 11.3 stopped in week 10)

Height of leaves, height of flowers and number of buds and flowers: Plants exposed to supplementary and photoperiodic light were taller than plants exposed to ambient daylight. Storage had no influence on leaf height. Plants from forcing week 01 and from outdoors had the tallest flower stems (30 cm on average). All the other plants were around 5 cm shorter, with the plants exposed to ambient daylight being the shortest (13 cm on average). The flower stem length was shortened due to insufficient vernalisation. Supplementary light and photoperiodic light compensates for any lack of vernalisation. Storage had no real influence on flower height. Each flower stem gave rise to several flowers (Figure 47). There were always one flower stem per plant and sometimes a second flower stem was also visible.

General value: Plants exposed to supplementary light and photoperiodic light scored better (6 to 7) than plants exposed to ambient daylight (4 to 6). Plants from the frost-free glasshouse scored better than plants from the polythene tunnel.

Shelf life test: The shortest time in shelf life was 19 days and the longest 26 days (average 20 days). *Aquilegia vulgaris* 'Winky Double White-White' is suitable for living room conditions.

***Aquilegia vulgaris* 'Winky Double White-White' and growth regulator treatments** (only the higher application rates were tested).
Forcing treatment: no influence

Height of leaves, height of flowers and number of buds and flowers: Topflor (2x) and CCC 720 (2x) had a little influence on leaf height. Plants were about 2 cm shorter than untreated plants. Plants treated with CCC (2x) had flower stems about 3 cm shorter than the untreated plants.

General value: no influence.

Recommendation for *Aquilegia vulgaris* 'Winky Double White-White': Potting should be completed by week 36, it maybe better to pot earlier to ensure sufficient plant size prior to vernalisation and to improve the level of flowering. The 10 cm pot is adequate. Vernalisation is a must prior to forcing especially under ambient daylight. Supplementary and photoperiodic light can compensate for any lack of vernalisation. There is a relatively high labour input for cleaning prior to marketing. From a week 50 forcing under supplementary light plants will flower before Valentine's Day. The test with growth regulators was inconclusive this year.

***Erigeron karvinskianus* 'Stallone'**
This species has a sprawling rather than upright growth. The flowers are daisy like and are white and pink coloured (Figure 49). The date of flowering was recorded when three open flowers were present on a plant. This section evaluates only the trimmed *Erigeron karvinskianus* 'Stallone' (species number F13 gest) because the untrimmed plants scored very low marks in the general value assessment.

Figure 49: week 06; Erigeron karvinskianus 'Stallone'; supplementary light and no growth regulator treatment

Erigeron karvinskianus 'Stallone' and no growth regulator treatments

<u>Forcing treatment:</u> All of the plants came into flower. Plants exposed to supplementary light from forcing week 50 flowered in weeks 4 to 5 before Valentine's Day (Figure 50). Plants exposed to photoperiodic light flowered three weeks later and plants exposed to ambient daylight flowered 5 weeks later. The plants from forcing week 01 (especially the outdoor ones) had to re-grow having been frost damaged and therefore there was a delay in flowering. Plants exposed to photoperiodic light and ambient daylight from forcing week 50 were influenced by storage. Plants from the polythene tunnel were 1 week earlier than plants from the frost-free glasshouse.

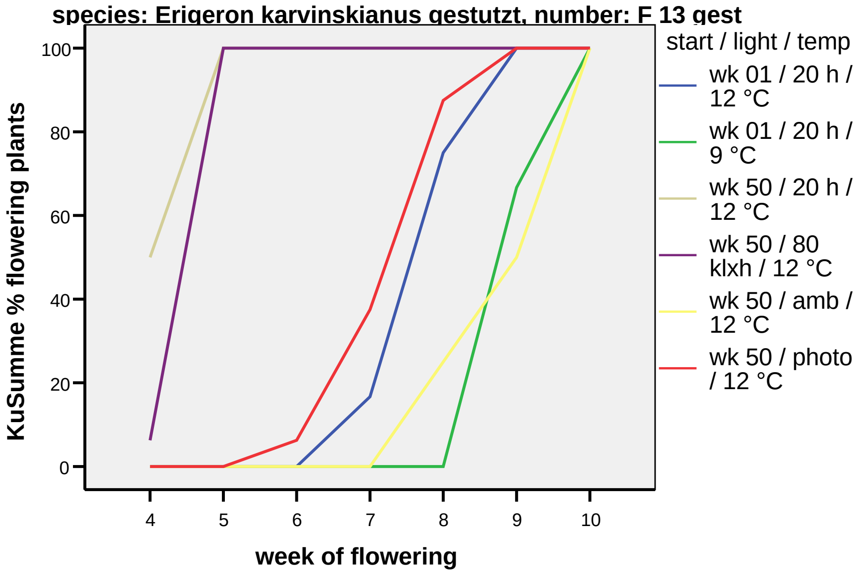

Figure 50: Percentage of flowering plants relative to the light treatments (photoperiodic lighting treatment H 11.3 stopped in week 10)

During last year's trial, plants exposed to supplementary light were 2 weeks later into flower and only plants from the polythene tunnel were ready for Valentine's Day. The reason for the earlier flowering this year is the earlier start of forcing and the greater light and temperatures sums over the trial period. Vernalisation seems to have an influence on *Erigeron karvinskianus* 'Stallone'.

Height of leaves, height of flowers and number of buds and flowers: The flowers occurred at the end of the stems so that the leaf height was similar to flower height. All the plants were about the same height (18 to 20 cm) except plants from forcing week 50 under 80 klxh and under photoperiodic light which were 5 to 7 cm longer, plants from the frost-free glasshouse.

General value: All the plants from forcing week 50 scored higher (6 to 7) than plants from forcing week 01. The longer period of lower temperatures was not advantageous for foliage quality, plants performed much better when they are kept in the frost-free glasshouse.

Shelf life test: The shortest time in shelf life was 25 days and the longest 32 days (average 29 days). *Erigeron karvinskianus* 'Stallone' is suitable for living room conditions.

***Erigeron karvinskianus* 'Stallone' and growth regulator treatments**

Forcing treatment: Plants treated with the higher application rate (2 x Topflor and 2 x CCC 720) had on average a one week delay in flowering compared to the untreated plants. Plants treated with the lower application rates (4 x Topflor and 4x CCC 720) had two weeks delay in flowering compared to the untreated plants.

Height of leaves, height of flowers and number of buds and flowers: Plants treated with Topflor were 8 to 9 cm shorter than untreated plants and plants treated with CCC 720 were 6 to 8 cm shorter than untreated plants (Figures 51 and 52).

Figure 51: week 05; *Erigeron karvinskianus* 'Stallone' left to right: 2x Topflor, 4x Topflor; 2x CCC 720, 4x CCC 720

Figure 52: week 05; *Erigeron karvinskianus* 'Stallone' left to right: untreated, 2x Topflor; 4x Topflor

General value: The application of growth regulators improved the general value compared to untreated plants.

Recommendation for *Erigeron karvinskianus* 'Stallone': Potting should be completed by week 36. Trimming is necessary for better performance. It is better to keep *Erigeron karvinskianus* 'Stallone' in a frost-free glasshouse (frost damages the leaves too much). The need of vernalization is unclear but it appears to be advantageous. The cleaning requirement prior to marketing is minimal. Plants forced during week 50 at 10°C to 12°C and exposed to supplementary light will flower before Valentine's Day. The application of growth regulators (Topflor or CCC 720) is recommended to keep the plants compact.

***Geum coccineum* 'Cooky'**

This species has striking orange coloured flowers (Figure 53). The species is both attractive as a single plant and in arrangements. At the end of last year's trial it was recommended that it was better to pot plants earlier to give a higher flowering percentage. However, plants were potted 6 weeks earlier this year and although larger developed few flowers without supplementary lighting. This may indicate a need to produce a large plant prior to flower initiation. The other possibility is that the plants received insufficient vernalisation during storage in both years of the trial. Supplementary light was able to compensate some way for a lack of vernalisation with some of the plants. Plants from forcing week 01, exposed to supplementary light and from the polythene tunnel and outdoors all flowered. The date of flowering was recorded when there was one open flower per plant.

Geum coccineum 'Cooky' and no growth regulator treatments

Forcing treatment: Plants exposed to supplementary light flowered on average after 31 days. Plants from forcing week 50 exposed to supplementary light flowered in weeks 2 to 4 and from forcing week 01 in weeks 4 to 5. Plants exposed to photoperiodic light and ambient daylight flowered over a long period. Only some plants flowered before Valentine's Day (Figure 54).

Height of leaves, height of flowers and number of buds and flowers: Plants exposed to supplementary light were 1 to 2 cm taller compared to plants exposed to ambient daylight and photoperiodic light. The storage treatment had no influence. Flower height was about the same for all treatments (at 18cm) except plants exposed to ambient daylight, which had shorter flower stems (around 13cm). Plants from forcing week 01 had on average 2 to 5 flower buds more per plant than plants from forcing week 50 exposed to supplementary, photoperiodic and ambient daylight. Plants developed more buds when they were from the polythene tunnel and then exposed to supplementary light. Supplementary light compensated for any lack of vernalisation, especially in the case of plants from polythene tunnel. This indicates a need for vernalisation.

Figure 53: week 02; *Geum coccineum* 'Cooky'; supplementary light; polythene tunnel

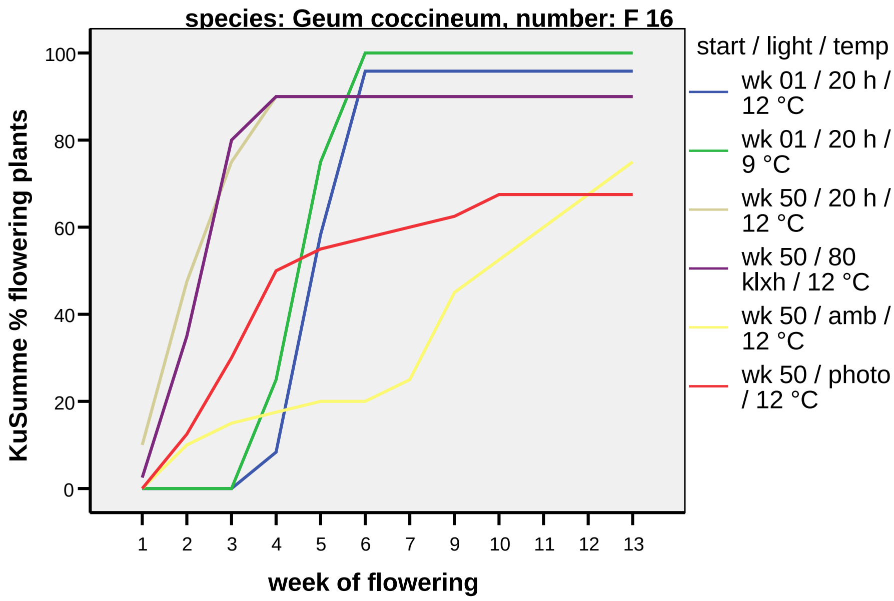

Figure 54: Percentage of flowering plants relative to the light treatments (photoperiodic lighting treatment H 11.3 stopped in week 10)

General value: Plants exposed to supplementary light scored better (6 to 7) than plants exposed to ambient and photoperiodic light (5 to 6). Storage was only significant in the glasshouse H 11.1, plants from the polythene tunnel scored better (7) compared to plants from the frost-free glasshouse (6).

Shelf life test: The shortest time in shelf life was 11 days and the longest 15 days (average 11 days). *Geum coccineum* 'Cooky' is suitable for living room conditions.

Geum coccineum 'Cooky' and growth regulator treatments
Forcing treatment: no influence.

Height of leaves, height of flowers and number of buds and flowers: Plants treated with 2 x CCC 720 were on average a little shorter (1 cm) than untreated plants. Plants treated 2 and 4 times with CCC 720 had shorter flower stems than untreated plants (on average 3-4cm). Topflor had no significant effect (Figure 55).

General value: no influence.

Figure 55: week 05; *Geum coccineum* 'Cooky' left to right: 2x Topflor; 4x Topflor; 2x CCC 720; 4 x CCC 720; supplementary light (H 11.1)

Recommendation for *Geum coccineum* 'Cooky': Potting should be completed by week 36. The plant needs to be of a sufficient size prior to vernalisation. Plants should be stored for at least 10 weeks, as cool as possible. Vernalisation is an important requirement for flower production at Valentine's Day. There is a minimal requirement for cleaning prior to marketing. Supplementary light is able to compensate for any lack of vernalisation. There is a requirement for further testing of growth regulators to control flower stem length.

Michigan State University tested *Geum chiloense* 'Mrs Bradshaw'. Trials indicated this species was day-neutral and vernalisation was a requirement (no plants flowered without it). The vernalisation treatment was 15 weeks at 5°C under controlled conditions. The plants subsequently flowered after 8 weeks at 20°C.

Horminum pyrenaicum

This species has green rosettes of leaves and violet-blue flowers carried on a flower stem (Figure 56). This species attracted attention in previous trials and was tested this year to force an earlier flower and to evaluate its reaction to the growth regulator treatments. Unfortunately this year the rosettes were potted too deep which encouraged fungal diseases. Vernalisation was also insufficient during storage. However, supplementary light was able to compensate for any lack of vernalisation and many plants flowered before Valentine's Day. There was insufficient data collected this year to produce a recommendation for it. The date of flowering was recorded when there were three open flowers per single flower stem.

Figure 56: week 07; *Horminum pyrenaicum* ; supplementary light; start of forcing week 01; outdoor

Horminum pyrenaicum and no growth regulator treatments

Forcing treatment: Plants exposed to supplementary light were 4 to 5 weeks earlier than plants exposed to photoperiodic light and 7 to 8 weeks earlier than plants exposed to ambient daylight (Figure 57). The storage treatments had no influence. Plants from forcing week 50 at 12°C came into flower first (after 40 to 43 days) compared to the plants exposed to 80 klxh and plants exposed to supplementary light from forcing week 01 (50 days). There is a correlation between temperature and light, the higher the temperature and light sums the faster flowering occurs.

Height of leaves, height of flowers and number of buds and flowers: There was no real influence on leaf height. Plants from ambient daylight were a little shorter (2cm) than plants exposed to supplementary light. The storage treatment had no influence on leaf height. Flower spikes were taller (up to 22 cm) on plants from forcing week 01 (outdoor) and supplementary light compared to plants from forcing week 50 (14 to 16 cm). More vernalisation increases flower stem height. Plants from forcing week 50 exposed to ambient daylight had the shortest flower stems often sitting between the leaves. The storage treatment had no influence on flower height. In most cases, there was one flower and sometimes one bud visible.

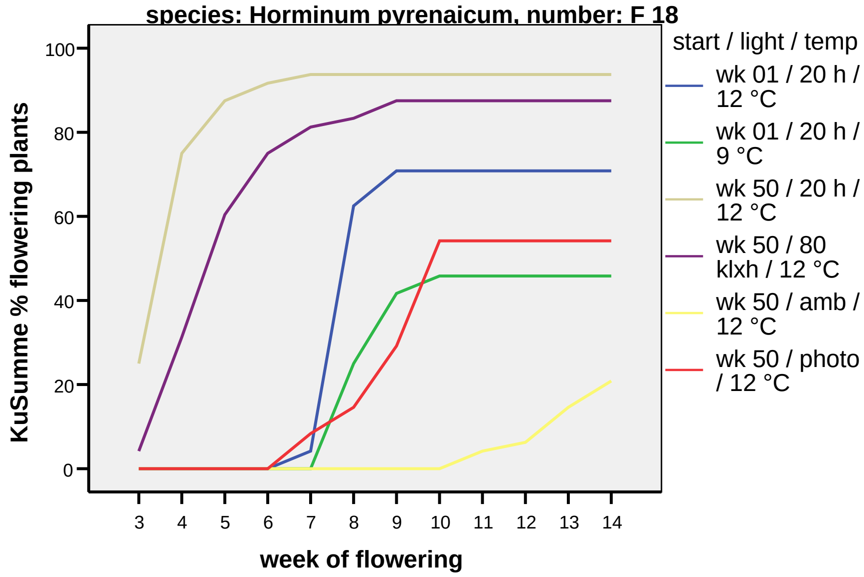

Figure 57: Percentage of flowering plants relative to the light treatments
(photoperiodic lighting treatment H 11.3 stopped in week 10)

General value: The plants scored about the same (5 to 6). The lowest general value score was for plants from forcing week 01 at 12°C because the flower stems were too high in correlation to the small leave rosettes.

Shelf life test: The shortest time in shelf life was 11 days and the longest 22 days (average 14 days). *Horminum pyrenaicum* is suitable for living room conditions.

Horminum pyrenaicum and growth regulator treatments
Forcing treatment: no influence.

Height of leaves, height of flowers and number of buds and flowers: Plants treated with 2 x CCC 720 were 1 to 2 cm shorter than the other treated and untreated plants. There was no real influence of the growth regulators on flower stem height on average. (Plants from forcing week 50 exposed to supplementary light were slightly shorter in response to Topflor and CCC 720 relative to the untreated plants). As a result of insufficient vernalisation during storage, it is not possible draw any conclusive results. Further work is required to test growth regulators.

General value: no influence.

Recommendation for *Horminum pyrenaicum*: Potting should be completed by week 28 so that the plants can attain a sufficient size prior to vernalisation. Three plants per 12 cm pot are better for performance and flowering. (One plant is able to fill a 9 cm pot size) Vernalisation should be for at least 10 weeks at 5°C, even then flowering may not occur until mid-March. Supplementary light can compensate for the lack of any vernalisation. The correlation between light and temperature sums can dictate plant development. There is a moderate need for cleaning prior to marketing. From a week 50 forcing (at least) at 12°C, it is possible to induce flowering before Valentine's Day. There may be a possibility to shorten the length of flower stems with growth regulators. There is a need for further evaluation in the future.

***Lithodora diffusa* 'Heavenly Blue'**
This species has attractive blue flowers (Figures 59 and 60). The species has been evaluated over several years. However this year, the cuttings took a long time to root and as a consequence the plants were potted late (week 38) and did not fill the pot size (Figure 58). All the plants came into flower except some plants exposed to photoperiodic light from frost-free glasshouse because the scoring finished in week 9 in this glasshouse compartment. The date of flowering was recorded when three open flowers per plant was achieved.

Figure 58: week 50; *Lithodora diffusa* 'Heavenly Blue'; polythene tunnel

Figure 59: week 08; *Lithodora diffusa* 'Heavenly Blue'

Figure 60: Close up of flower

***Lithodora diffusa* 'Heavenly Blue' and no growth regulator treatments**
Forcing treatment: Plants from forcing week 01 exposed to supplementary light were over 1 week quicker into flower (around 52 days) than plants from forcing week 50 also exposed to supplementary light (around 62 days). Vernalisation forces the plants into flower earlier. Plants from forcing week 50 exposed to supplementary light from the polythene tunnel flowered in time for Valentine's

Day (Figure 61). Plants exposed to photoperiodic light were almost one week earlier (flowered weeks 9-10) than plants exposed to ambient daylight (flowered weeks 10 to 11). The storage treatment had an effect in glasshouse H 11.2 (80klxh) and H 11.3 (photoperiodic). Plants from the polythene tunnel flowered one week quicker than plants from the frost-free glasshouse.

Height of leaves, height of flowers and number of buds and flowers: The flowers occurred at the end of the stems therefore leaf and flower heights were comparable. All the plants exposed to photoperiodic and supplementary light were taller than plants exposed to ambient daylight. Plants from forcing week 01 were better branched (10 to 11 branches) than plants from forcing week 50 (8 to 9 branches). Plants from forcing week 50 exposed to supplementary light were better branched when stored in the polythene tunnel compared to the frost-free glasshouse. This indicates the importance of vernalisation during storage.

General value: All the plants scored about the same (5 to 6). Only plants exposed to photoperiodic light scored a little lower (4-5) as the plants were more open in growth. Plants from forcing week 50 from the polythene tunnel scored better than plants from the frost-free glasshouse.

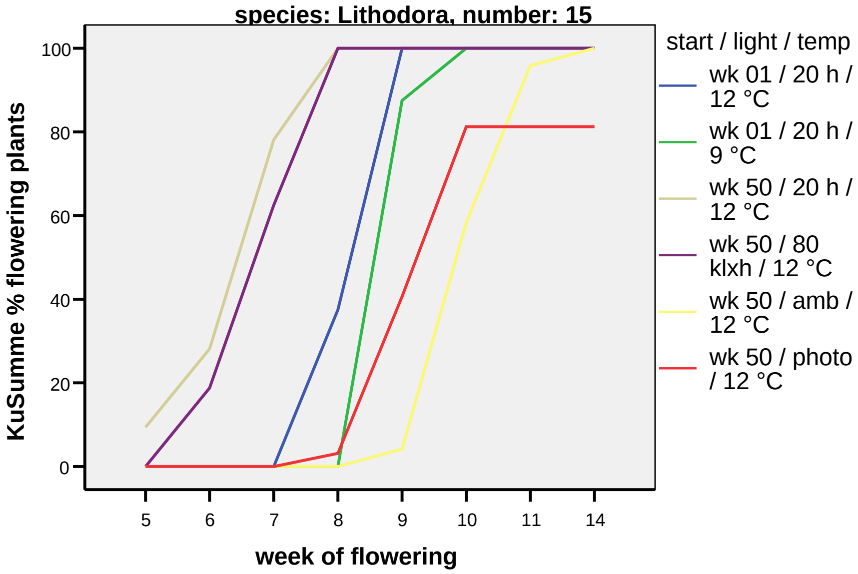

Figure 61: Percentage of flowering plants relative to the light treatments
(photoperiodic lighting treatment H 11.3 stopped in week 10)

Shelf life test: The shortest time in shelf life was 14 days and the longest 19 days (average 18 days). *Lithodora diffusa* 'Heavenly Blue' is suitable for living room conditions.

***Lithodora diffusa* 'Heavenly Blue' and growth regulator treatments**

Forcing treatment: All the plants treated with growth regulators had a half to one week delay in flowering.

Height of leaves, height of flowers and number of buds and flowers: The growth regulator treatments had an influence on plants exposed to supplementary and photoperiodic light (Figure 62). Plants treated with Topflor were 2 to 3 cm shorter than the untreated plants (Figure 64). Plants treated with CCC 720 were 1 to 2 cm shorter than untreated plants (Figure 63). The lower application rate was a little more successful with both Topflor and CCC 720 than the higher application rate.

General value: no influence.

Recommendation for *Lithodora diffusa* 'Heavenly Blue': Potting should be completed by week 30 to allow the plants to be trimmed twice. Trimming produces a better branched plant more able to fill a 9 to 10 cm pot. Three rooted cuttings can be used in a 12 cm pot. The substrate should have a lower pH (4.5 to 5.5). The fertiliser levels should not be above 200 mg N per plant. Vernalisation is important, Lithodora needs to be as cool as possible (but not under -5°C) for 9 to 10 weeks. Improved levels of vernalisation generates more branching and flowering during the forcing period. Lithodora is day-neutral and responds to light and temperatures sums during forcing. There is minimal cleaning required prior to marketing. From a start of forcing in week 50 (with high initial temperatures for about 72 hours, around 20°C), at 12°C using supplementary light, the plants will flower for Valentine's Day. It is possible to keep the plants more compact with growth regulators (Topflor and CCC 720) under supplementary light. Plants exposed to ambient daylight at 12°C will flower in the middle of March.

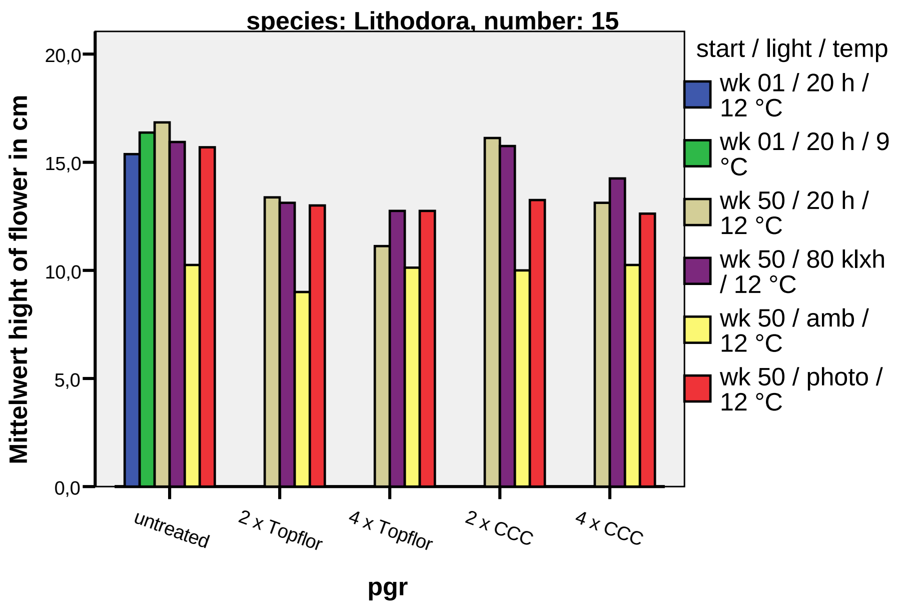

Figure 62: Diagram of the average flower height in cm; *Lithodora diffusa* 'Heavenly Blue'

Figure 63: week 07; *Lithodora diffusa* 'Heavenly Blue'; supplementary light; left to right: 2x Topflor; 4x Topflor; 2x CCC 720; 4x CCC 720

Figure 64: week 07; *Lithodora diffusa* 'Heavenly Blue'; supplementary light; left to right: untreated; 2x Topflor; 4x Topflor

***Papaver miyabeanum* 'Pacino'**

This species has light yellow lemon flowers (Figure 65). It is one of the compact growing species of papaver and that makes it interesting as an early spring pot plant. It performs well as a single plant and in arrangements. When flowers are withered, the seed heads look still interesting. Papaver requires a long day. All the plants flowered except those exposed to ambient daylight. The date of flowering was recorded when there was one open flower per plant.

Figure 65: week 04; *Papaver miyabeanum* 'Pacino'; supplementary light

Papaver miyabeanum 'Pacino' and no growth regulator treatments

Forcing treatment: All the plants exposed to supplementary light (20h-3000lx) at 12°C flowered after 35 days. Plants exposed to 80 klxh at 12°C and plants exposed to 20h-3000lx at 9°C had an almost one week delay in flowering. Plants exposed to photoperiodic light flowered with two weeks delay. Plants exposed to supplementary light flowered before Valentine's Day (Figure 66). Plants exposed to the photoperiodic light flowered over a longer period and not all the plants had flowered by Valentine's Day. Plants exposed to supplementary light from forcing week 50 flowered earlier than in previous trials as a result of higher temperatures and light sums prior to flowering.

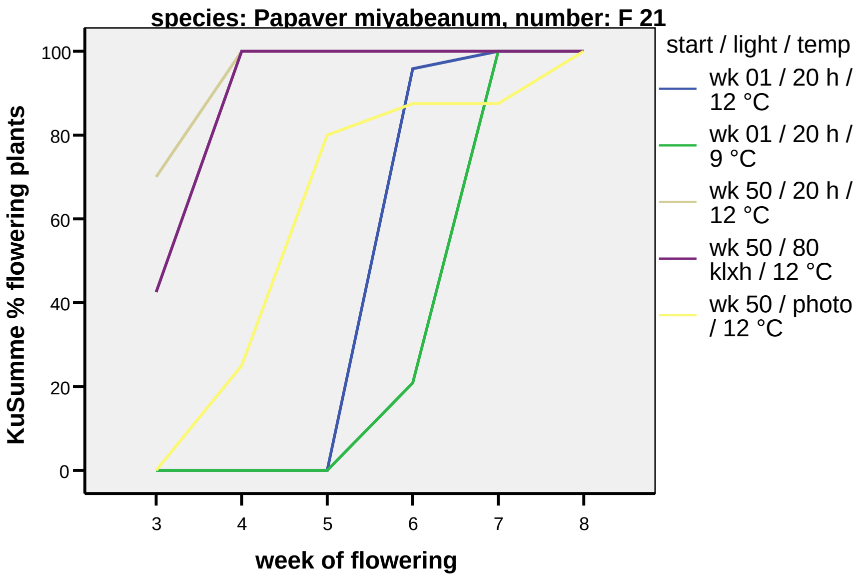

Figure 66: Percentage of flowering plants relative to the light treatments
(photoperiodic lighting treatment H 11.3 stopped in week 10)

Height of leaves, height of flowers and number of buds and flowers: Leaf height (about 9 cm) and flower height (about 18 cm) were about the same across treatments, except plants exposed to photoperiodic light. These plants were taller in terms of both leaf height (12 cm) and flower height (22 cm). The number of buds and flowers was about the same for all treatments except plants exposed to photoperiodic light, which had on average 2 buds less. The storage treatment had no real influence on leaf height. The plants from the polythene tunnel from forcing week 50 were 2 cm shorter than plants from the frost-free glasshouse.

General value: All the plants scored about 6 to 7 except plants exposed to photoperiodic light, which scored an average of 5. The plants were more open in growth under photoperiodic light.

Shelf life test: The shortest time in shelf life was 7 days and the longest 15 days (average 14 days). The duration of shelf life depended upon the number of buds that were able to open up in shelf life room. *Papaver miyabeanum* 'Pacino' is suitable for living room conditions.

***Papaver miyabeanum* 'Pacino' and growth regulator treatments**

Forcing treatment: no influence.

Height of leaves, height of flowers and number of buds and flowers: There was no influence on leaf height. Plants treated with the higher application rate of Topflor were about 3 cm shorter and those treated with CCC 720 about 2 cm shorter than the untreated plants.

General value: no influence.

Recommendation for *Papaver miyabeanum* 'Pacino': Potting should be completed by week 32 to allow the plants to fill a 10cm pot. A number of plants per pot could produce a better display in terms of flower and bud. It is not known how important vernalisation is for papaver. Plants should be kept frost-protected, as it results in less cleaning prior to marketing, although the requirement is still high. Plants exposed to supplementary light at 12°C from forcing in week 50 will flower before Valentine's Day.

***Papaver nudicaule* 'Garden Gnome'**

The clear vibrant colours of these variety were striking, although single plants were not so attractive because of the high flower stems above the leaves. However, in arrangements as a background plant or as a cut flower, the crop could be interesting (Figures 67 and 68). Papaver requires a long day to initiate flowering. All plants flowered except the plants exposed to ambient daylight.

 

Figure 67 and Figure 68: left: week 03; *Papaver nudicaule* 'Garden Gnome'; supplementary light; right: February 2007; *Papaver nudicaule* 'Garden Gnome' in arrangement at fairy floriga Leipzig 2007

Papaver nudicaule 'Garden Gnome' and no growth regulator treatments

Forcing treatment: Plants exposed to supplementary light (20h-3000lx) at 12°C flowered after 32 to 35 days. Plants exposed to 80klxh at 12°C and plants with 20h-3000lx at 9°C flowered with after 40 days. This demonstrates the correlation between temperatures and light and the duration of forcing prior to flowering. Plants exposed to photoperiodic light flowered 3 to 4 weeks later over a longer period of time. All plants exposed to supplementary light from forcing week 50 and week 01 at 12°C came into flower by Valentine's Day (Figure 69). The crop was earlier than last year because of the greater light and temperature sums prior to flowering.

Height of leaves, height of flowers and number of buds and flowers: There was no influence on leaf height, all the plants were around 14 cm in height. The plants exposed to photoperiodic light had flower stems 5 to 7 cm taller (approximately 38cm) compared to plants exposed to supplementary light (approximately 32 cm). The storage treatment had no influence, on flower stem height but it did influence the number of buds and flowers. Plants exposed to photoperiodic light also developed about 2 buds less (bout 5-7 buds) than plants exposed to the other treatments.

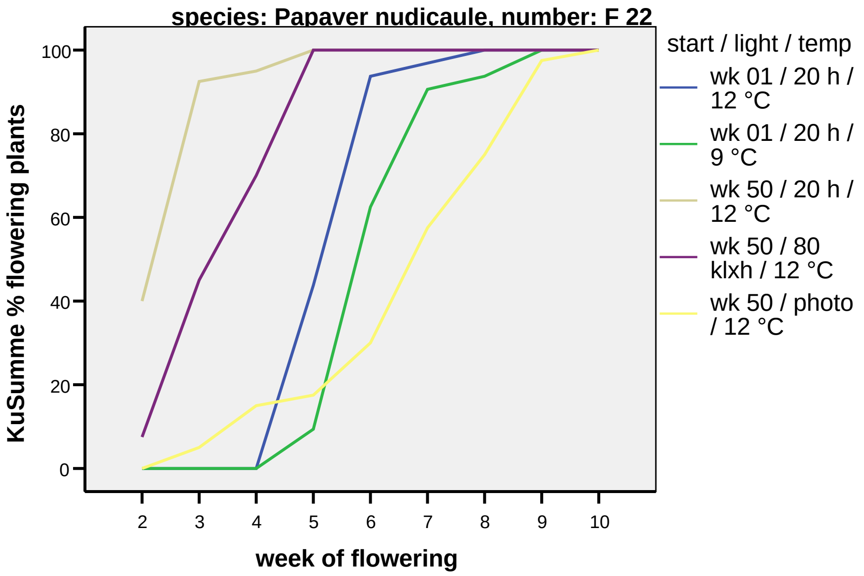

Figure 69: Percentage of flowering plants relative to the light treatments
(photoperiodic lighting treatment H 11.3 stopped in week 10)

General value: All the plants scored about the same (5 to 6) except plants exposed to photoperiodic light, which scored 4 to 5 because of the stretched flower stems.

Shelf life test: The shortest time in shelf life was 11 days and the longest 15 days (average 13 days). The duration of shelf life depended upon the number of buds that were able to open up in shelf life room. *Papaver nudicaule* 'Garden Gnome' is suitable for living room conditions.

***Papaver nudicaule* 'Garden Gnome' and growth regulator treatments**
The objective was to shorten the flower stems using the growth regulators, but there was no response to either Topflor or CCC 720.

Forcing treatment: no influence.

Height of leaves, height of flowers and number of buds and flowers: no real influence on leaf or flower height.

General value: no influence

Recommendation for *Papaver nudicaule* 'Garden Gnome': Potting should be completed by week 32 so that the plants can fill a 10 cm pot. More plants in a larger pot would produce a better balanced product. Storage is better under frost-free conditions. The need for vernalisation is not clear. Papaver is a long-day plant, so there will be no flowering under ambient daylight until week 14 onwards. The requirement for cleaning prior to marketing is high. Plants exposed to supplementary light at 12°C from forcing week 50 will flower before Valentine's Day. There is no recommendation for using Topflor or CC 720.

Phlox divaricata
This species produces many sky-blue sweetly scented flowers (Figures 70 and 71). This species could be an attractive early spring pot plant, however the main disadvantage is flower height, the plants require supporting. This was the first

trial to examine the effect of growth regulators on the variety. Plants exposed to supplementary light flowered before Valentine's Day. Species number 24 were tiny divided plants grown in plug trays from week 27 until potting. Species number 26 were cuttings from divided stock plants and were also propagated in week 27. Plant development was comparable and they both achieved similar results. The following section covers both *Phlox divaricata* (24) and *Phlox divaricata* (26).

Phlox divaricata and no growth regulator treatments

Forcing treatment: All the plants exposed to supplementary light at 12°C flowered on average after 38 days. Plants from forcing week 50 exposed to supplementary light flowered early in weeks 3 to 4. Plants from forcing week 01 at 12°C flowered just before Valentine's Day in weeks 5 to 7 (Figure 72). Plants from forcing week 01 at 9°C had a one week delay. Plants exposed to photoperiodic light flowered on average 2 weeks later than plants exposed to supplementary light and flowered over a longer period. Plants exposed to ambient daylight from the polythene tunnel were on average 7 weeks later and flowered in weeks 11 to 12 (much later than in previous trials), some plants from the frost-free glasshouse did not flower at all during the trial. An explanation for this could be the lack of vernalisation during storage. The supplementary and photoperiodic lighting appears to be able to compensate for this lack of vernalisation.

Figure 70 and Figure 71: week 03, *Phlox divaricata* (24); supplementary light;
left: 1 plant per pot; right: 2 plants per pot

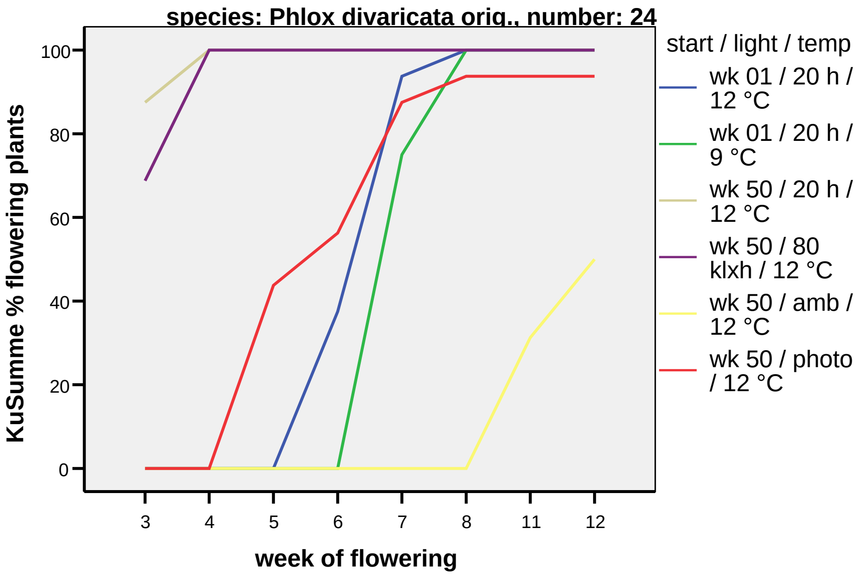

Figure 72: Percentage of flowering plants relative to the light treatments
(photoperiodic lighting treatment H 11.3 stopped in week 10)

<u>Height of leaves, height of flowers and number of buds and flowers:</u> As the flowers occurred at the end of the shoots, leaf and flower height were approximately comparable. The plants from forcing week 50 exposed to supplementary light and photoperiodic light were about the same height (approximately 32 to 34 cm). Plants from forcing week 01 were 6 to 8 cm taller (37 to 38cm) than plants from forcing week 50. Plants that had received more vernalisation tended to be taller. Plants exposed to ambient daylight from forcing week 50 were 15 cm shorter than plants exposed to supplementary light (Figure 73).

Figure 73: week 11, *Phlox divaricata* (24), ambient daylight from polythene tunnel

<u>General value:</u> Plants scored lower than in previous years because there was less structure to them and insufficient branching. Plants exposed to ambient daylight scored better (5 to 6) because of the compact growth compared to plants from the other treatments (4 to 5).

Shelf life test: The shortest time in shelf life was 19 days and the longest 24 days (average 19 days). *Phlox divaricata* is suitable for living room conditions.

Phlox divaricata and growth regulator treatment

Forcing treatment: no influence.

Height of leaves, height of flowers and number of buds and flowers: Plants exposed to supplementary light and treated with 2 x and 4 x Topflor were 8 cm shorter on average than untreated plants (Figure 74). Plants exposed to supplementary light and treated with 2 x CCC and 4 x CCC were about 4 to 6 cm shorter than untreated plants. Plants exposed to ambient daylight were not influenced by the growth regulator treatments.

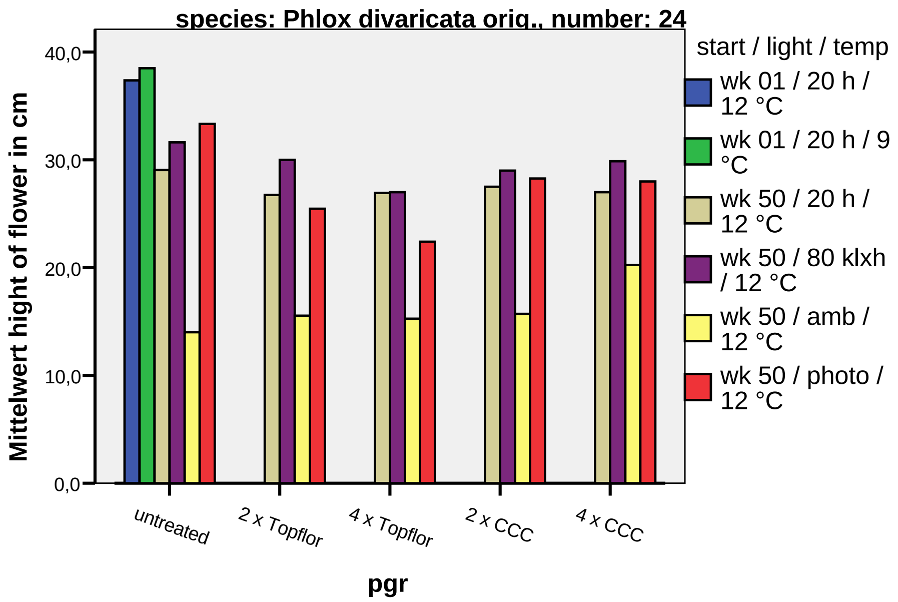

Figure 74: Diagram of the average flower height in cm; *Phlox divaricata*

General value: no influence.

Recommendation for *Phlox divaricata*: Potting should be completed by week 32 at the latest. Plants should be well developed to fill a 10 cm pot prior to vernalisation. Three rooted cuttings can be used in a 12 cm pot, as they perform better and develop more flowers. The use of growth regulators like Topflor and CCC 720 is recommended to control height. However, further tests with growth regulators on this species are required. Phlox needs vernalisation for at least 9 weeks at around about 5°C. The cleaning requirement prior to marketing is minimal. From a week 50 forcing at 12°C and with supplementary light plants should flower before Valentine's Day. Plants exposed to ambient daylight will flower at the beginning of March.

Michigan State University tested *Phlox divaricata* 'Laphammi', 'London Grove' and 'May Breeze'. Trials showed this species is day-neutral, and vernalisation is required. The vernalisation treatment tested was 15 weeks at 5°C. The plants flowered after 3 weeks at 20°C. The recommendation was for a prolonged 'bulking' to overcome juvenility prior to cooling.

***Silene pendula* 'Lausitz'**

This species was recommended as an early spring pot plant in previous years (2000 to 2003). The pink flowers are attractive (Figure 75) and the species can be used as a single plant or in arrangements. *Silene pendula* 'Lausitz' is a day-neutral plant that requires vernalisation. All the plants flowered with the exception of plants exposed to ambient daylight. The date of flowering was recorded when there were three open flowers per plant.

Figure 75: week 04; *Silene pendula* 'Lausitz'; supplementary light; 2x CCC 720

Silene pendula 'Lausitz' and no growth regulator treatments

Forcing treatment: Plants exposed to supplementary light at 12°C flowered after 44 to 49 days. The quickest to respond were plants from outdoors followed by plants from the polythene tunnel and then the frost-free glasshouse. (The more vernalisation received the earlier the flowering date). These plants flowered prior to Valentine's Day (Figure 76). Plants from forcing week 50 exposed to supplementary light flowered in weeks 4 to 5. Plants exposed to the 80klxh flowered in weeks 5 to 6. Plants from forcing week 01 at 12°C and 20h 3000lx flowered in weeks 5 to 6. Plants from forcing week 01 at 9°C (20h-3000lx) flowered in weeks 6 to 8 and did not all flower in time for Valentine's Day. Plants exposed to photoperiodic light flowered in weeks 6 to 9.

Height of leaves, height of flowers and number of buds and flowers: Flowers occurred at the end of branches therefore leaf and flower stem heights were comparable. Plants exposed to supplementary light were about the same height (15 to 16 cm). Plants from forcing week 01 (20h-3000lx) at 9°C and 12°C from outdoors were a little shorter (14 to 15 cm). This reduction of 1 to 2 cm was important as plants stood upright and branches did not tip over. Plants exposed to photoperiodic light were about 1 to 2 cm taller than plants exposed to supplementary light, leading to a poorer plant shape (Figure 77). Plants exposed to ambient daylight were shorter but developed more a creeping habit than the upright appearance in response to other treatments (Figure 78).

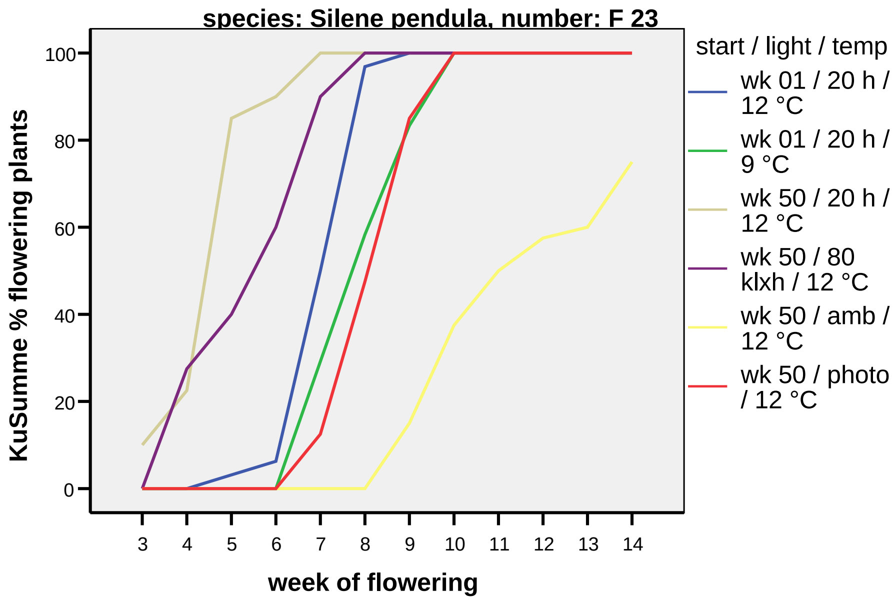

Figure 76: Percentage of flowering plants relative to the light treatments
(photoperiodic lighting treatment H 11.3 stopped in week 10)

Figure 77: week 09; *Silene pendula* 'Lausitz'; photoperiodic light

Figure 78: week 09; *Silene pendula* 'Lausitz'; ambient daylight

General value: Plants exposed to supplementary light scored about the same (6 to 7). Plants from forcing week 01 exposed to supplementary light and from outdoors scored on average a little better (6 to 8). Plant habit was better and the branches did not tip over. Plants exposed to ambient daylight scored 4 to 5 because of the uneven flowering per plant. Plants exposed to photoperiodic light all scored around 4 because the branches tipped over (Figure 77).

Shelf life test: The shortest time in shelf life was 11 days and the longest 21 days (average 14 days). *Silene pendula* 'Lausitz' is suitable for living room conditions. The bright pink colour of flowers keeps better under cooler conditions than those in the shelf life room.

Silene pendula 'Lausitz' and growth regulator treatments
Forcing treatment: no influence.

Height of leaves, height of flowers and number of buds and flowers: Plants exposed to ambient daylight were not influenced by the growth regulator treatments. The Topflor applications were not so successful, only plants treated with the higher application rate of Topflor were on average shorter (by 1 to 2 cm). The 2 x Topflor treatment was more effective on the glasshouse H 11.2 (80klxh) and H 11.3 (photoperiodic) treatments than on glasshouse H 11.1 (20h-3000lx) treatment. Plants exposed to supplementary and photoperiodic light responded more to the CCC 720 treatments (Figures 79 - 81). Plants treated with the higher application rate were 3 to 4 cm shorter whilst plants treated with the lower application rate were 2 cm shorter compared to the untreated plants.

General value: no influence.

Figure 79: week 05; *Silene pendula* 'Lausitz'; supplementary light; left to right: 2xTopflor; 4x Topflor; 2x CCC 720, 4x CCC 720

***Figure 80: week 05; Silene pendula* 'Lausitz'; supplementary light; left to right: untreated, 2xTopflor; 4x Topflor**

Figure 81: week 05; *Silene pendula* 'Lausitz'; supplementary light; left to right: untreated, 2x CCC 720, 4x CCC 720

Recommendation for *Silene pendula* 'Lausitz': Potting should be completed by week 31 so that plants are of a sufficient size prior to storage. A 10 cm pot size is adequate. Silene is a day-neutral plant that requires vernalisation. Plants should be stored for at least 6 weeks as cool as possible (about 5°C) in a frost-free glasshouse or in a polythene tunnel. With higher forcing temperatures, the flowers will be earlier but the plants stretch more and can tip over. In this case, a growth regulator treatment using CCC 720 is recommended. There is a moderate need to clean the plants prior to marketing. Forcing during week 50 at 10°C to 12°C with supplementary light will generate flower by Valentine's Day. Provided the plants are well vernalised and the ambient daylight is good through December, January and February the crop can even finish without supplementary light by Valentine's Day.

***Lychnis alpina* and *Lychnis alpina* 'Snow Furry'**

This pink flowering *Lychnis alpina* was a recommendable early spring pot plant from previous trials (2002/2003; Figure 84). *Lychnis alpina* 'Snow Furry' has white flowers. However, this year there was insufficient flower to allow evaluation. The reason was a lack of vernalisation until week 50. Flowers did not appear or were small and stunted (Figure 82). Supplementary light did not compensate for this lack of vernalisation. Plants from forcing week 01 received three weeks more vernalisation until forcing and the flower stems did develop under supplementary light (Figure 83).

The experiences from previous trials compared to this year's trial allows the conclusion that Lychnis has to be vernalised for at least 6 weeks with lower temperatures (about 5°C) before forcing. Provided the plants are vernalised, plants exposed to supplementary light (20h – 3000lx) at 12°C will flower after 43 to 47 days. Plants exposed to supplementary light at 9 to 10°C will flower after 53 to 55 days. The flower stems increase in length with higher forcing temperatures. There are no results regarding the response to growth regulators.

Figure 82: week 05; *Lychnis alpina* 'Snow Furry'; left: 2 x supplementary light ; right: 2 x photoperiodic light; start of forcing in week 50

Figure 83: week 07; *Lychnis alpina* 'Snow Furry'; supplementary light at 12 °C stored outdoors; start of forcing in week 01

Figure 84: week 09; *Lychnis alpina*; supplementary light at 9°C stored outdoors; start of forcing in week 01

3.3 Shelf life under living room conditions and frost hardiness test

The minimum requirement for shelf life was 7 days and all the species tested had a shelf life period under living room conditions longer than this period. 14 of the species even reached beyond 20 days. Table 9 summarises the results obtained.

The frost hardiness tests to which the plants were exposed indicate that plants which have been through the forcing treatment may be tolerant of temperatures down to 0°C but are damaged by lower temperatures. This indicates that the plants may not tolerate planting out into the garden during the late winter after they have finished flowering.

Table 9: Early spring pot plants and their shelf under living room conditions

Species / variety	Shelf life in days			
	n	Min.	Max.	average
Ajuga pyramidalis 'Metallica Crispa'	5	19	39	31
Ajuga reptans 'Braun Hertz'	5	21	31	27
Ajuga reptans 'Mini Mahagoni'	5	29	29	29
Anacyclus pyrethrum var. depressus 'Silberkissen'	5	14	26	22
Androsace septentrionalis 'Star Dust'	14	23	23	23
Aquilegia hybrida 'Spring Magic Blue-white'	5	15	15	15
Aquilegia hybrida 'Spring Magic Light red-white'	5	23	23	23
Aquilegia hybrida 'Spring Magic White'	5	15	26	22
Aquilegia vulgaris 'Winky Double White-White'	15	19	26	20
Arabis ferdinandi 'Old Gold'	5	19	19	19
Barbarea rupicola 'Sunnyola'	5	11	19	17
Calceolaria biflora 'Goldcap'	4	21	31	26
Cymbalaria 'Muralis'	5	24	24	24
Erigeron karvinskianus 'Stallone'	15	25	32	29
Erinus alpinus 'Dr. Hähnle'	5	13	13	13
Erysimum perovskianum 'Goldrush'	5	19	39	28
Geum coccineum 'Cooky'	15	11	15	11
Horminum pyrenaicum	15	11	22	14
Horminum pyrenaicum 'Rubrum'	5	11	19	17
Iberis sempervirens 'Snow Flake'	5	11	14	13
Lindernia 'Grandiflora'	5	38	47	43
Lithodora diffusa 'Heavenly Blue'	5	14	19	18
Lithodora diffusa 'Pete's Favorite'	5	13	13	13
Lychnis alpina	10	10	24	19
Lychnis alpina 'Snow Furry'	15	3	24	13
Papaver miyabeanum 'Pacino'	15	7	15	9
Papaver nudicaule 'Garden gnome'	15	11	15	13
Phlox divaricata original	15	19	22	19
Phlox divaricata Abvermehrung	15	19	22	19
Serissa foetida 'Pink Mystic'	5	19	24	22
Silene pendula 'Lausitz'	15	11	21	14

n = number of plants tested.

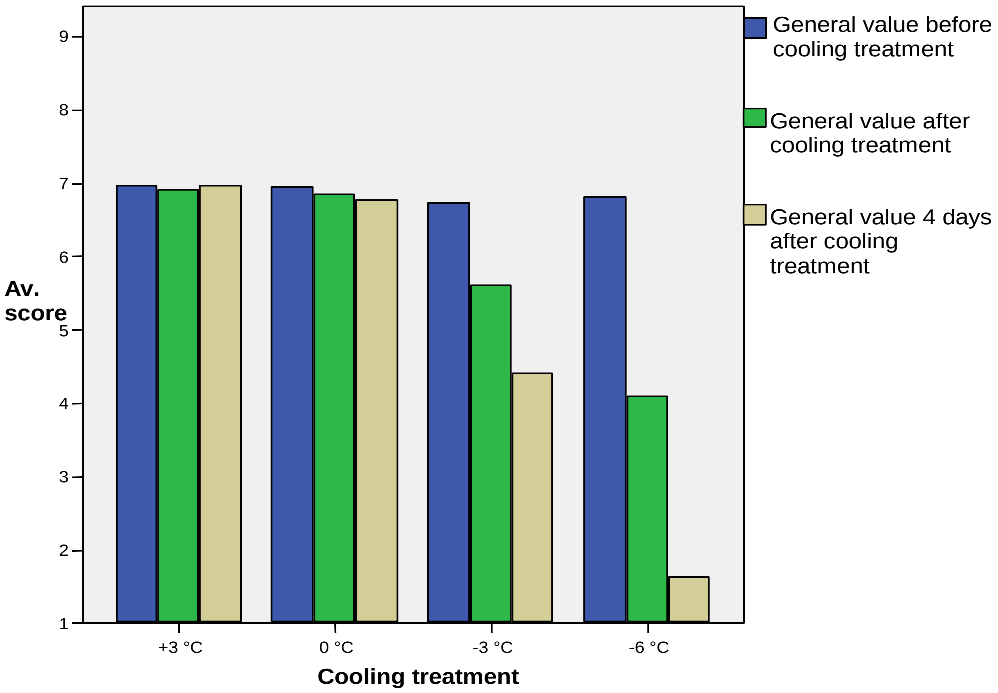

Figure 85: Effect of frost hardiness test on general value of early spring species a short time after their forcing treatment in the glasshouse (29 species/varieties, general value: 1 = very bad to 9 = perfect)

Figure 85 shows the effect of the frost hardiness test applied to plants shortly after their forcing treatment, Figure 86 shows the effect of the frost hardiness test after the shelf life evaluation (hence the lower plant values after shelf life onwards). Species that were more tolerant of the cold after the forcing treatment included –

- *Barbarea rupicola* 'Sunnyola'
- *Ajuga pyramidalis* 'Metallica Crispa'
- *Ajuga reptans* 'Braun Hertz'
- *Anacyclus pyrethrum var. depressus* 'Silberkissen'
- *Androsace septentrionalis* 'Star Dust'
- *Geum coccineum* 'Cooky'
- *Ajuga reptans* 'Mini Mahagoni'
- *Aquilegia vulgaris* 'Winky Double White-White'
- *Calceolaria biflora* 'Goldcap'

Only Androsace and Geum were tolerant after the shelf life treatment.

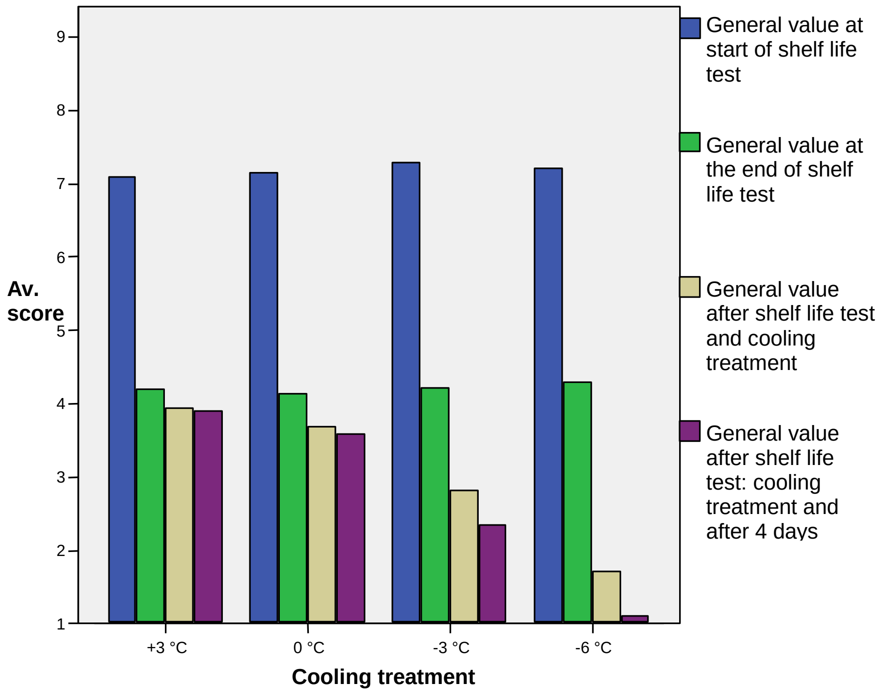

Figure 86: Effect of frost hardiness test on general value of early spring species after shelf life test under living room conditions (29 species/varieties, general value: 1 = very bad to 9 = perfect)

3.4 Economic calculations

The last economic calculation for early spring pot plants was made in 2003 for trials undertaken at Dresden-Pillnitz. They showed how the higher costs for energy changed the situation for early spring pot plants production during the trial. The results give growers an idea about the financial benefits of the cultivation of early spring pot plants. The calculations were created with the help of a database and software for pot plant production by Arbeitskreis Betriebswirtschaft Hannover e.V. The calculations were based on the production of 1000 saleable pot plants, using the following basic data:

Greenhouse: 1000 m²; single-layer energy screen, 90 % area
Marketing charge: 10 %
Costs for transport: 15 %
Hourly labour cost: 7 Euro per hour
Heating oil: 0.50 Euro/ litre
Electricity: 0.15 Euro/ kwh
Pot size: 10 cm
Potting: 500 pots per hour, week 32
Moving: 400 pots per hour, week 40
Moving and cleaning: 300 pots per hour, week 50
Supplementary light use: forcing periods of 2006/2007
Storage until week 50: polythene tunnel
Examples 1 to 3 in Table 10 are based on the purchase of young plants, that were seed propagated like *Andosace septentrionalis, Papaver nudicaule, Papaver miyabeanum, Silene pendula, Calceolaria biflora* and *Lychnis alpina* under the cultivation conditions used during the year. With the exception of papaver, costs of production under ambient day light conditions for all species are also included (example 3).

Plants came into flower earlier this year (2007) than in previous years as a result of the higher forcing temperature (and milder temperatures), the lighting treatment started at the same time as in previous years. The 72 hours of higher temperatures were calculated by assuming this equated to 15 °C for one week (week 50). Example 2, with the lighting treatment of 80 klxh per day, saves electricity but flowering commences one week later than example 1 and as a result the costs for oil are higher. This is why the net margin figures (net margin = gross margin less direct labour and machinery cost) are about the same. The calculated net margin figure is based on the price of 1 Euro per pot. Plants were sold at a wholesale market. As a larger pot size was used this year the marketing charge was higher. In 2003 the calculation used a 9 cm pot size and a price of 0,80 Euro (wholesale), this generated a much higher net margin (~ 350 Euro). The same margin would be possible with a price of 1,20 Euro per 10 cm pot. The example 3 with the ambient daylight makes a higher margin possible, but the selling date is later as a consequence.

The examples 4 to 6 in Table 12 are based on the purchase of young plants, which were seed propagated like *Anacyclus pyrethrum var. depressus*, *Horminum pyrenaicum, Erinus alpinus*. These species begin flowering later and need more space and lighting during the forcing period. The margin was calculated based on 1,20 Euro per pot. The net margin was not very high with the supplementary light. However, the supplementary lighting is essential for flowering at Valentine's Day.

The examples 7 to 9 in table (Table 13) are based on young plants, which have a higher cost price and are vegetatively propagated like *Ajuga reptans* and *Lithodoa diffusa* or seed propagated like *Aquilegia* hybrida. The calculated net margin is based on a selling price of 1,30 Euro (wholesale). These species are special and have to be sold as high value plants for Valentine's Day.

These are only examples and growers have to take account of their own businesses and production conditions. The advantage of using supplementary light is the earlier selling date and flowering period uniformity. If supplementary light is already installed it should be used. During 2007 a couple of growers in the Dresden area with their own florist outlet marketed the new species. The average retail price achieved was 2,30 Euro. The highest price was 3,25 Euro for *Calceolaria biflora* 'Goldcap', the Aquilegia was also successful and achieved 2,75 Euro whilst the Androsace was sold for 1,80 Euro to 2,75 Euro. Many customers, often from the older generation, were surprised about the early marketing period for the plants based on their knowledge of garden perennials. They found it difficult to imagine the plants as new pot plants for the living room. To address this, promotion and advertising will be necessary. However, other customers accepted the plants as early flowering indoor pot plants.

Table 10: Economic calculations, examples 1 to 3

Examples		**1** 20 h 3000lx	**2** 80 klxh	**3** ambient daylight
start	week	32	32	32
start of sale	week	3	4	6
end of sale	week	5	6	9
duration of crop	weeks	26	27	30
plants/m²	start>end	62>49	62>49	62>49
area net	m² x days	3318	3465	3906
amount for sale	pots	1000	1000	1000
selling rate at the market	in %	95	95	95
revenue	**€**	**950**	**950**	**950**
oil	litre	499	545	670
oil costs	€	250	272	335
seeds and plants				
seedlings	unit	1050	1050	1050
price	€/unit	0.10	0.10	0.10
costs of seedlings	€	105	105	105
pots and substrates				
size of pots		10 cm	10 cm	10 cm
number of pots	units	1050	1050	1050
costs of pots	€	32	32	32
amount of substrate	litre	431	431	431
costs of substrate	€	20	20	20
fertilisation, plant protection				
water, fertiliser (low level)	€	6	6	6
plant protection (low level)	€	8	9	10
lighting	W/m²	50	50	
lighted area	m²	20	20	
lighting duration	h	1030	840	
costs of lighting	€	155	126	
selling				
package	units	125	125	125
costs of package	€	23	23	23
marketing charge	€	95	95	95
summary of direct costs	**€**	**692**	**687**	**625**
manpower	hours	12.1	12.2	12.5
costs of manpower	€	85	85	71
output without direct costs	€	258	263	325
- per hour manpower	€/hour	21	22	26
- per area	€/1000 m² x days	78	76	83
net margin	**€**	**173**	**178**	**238**

Table 11: Economic calculations, examples 4 to 6

Examples		**4** 20 h 3000lx	**5** 80 klxh	**6** ambient daylight
start	week	32	32	32
start of sale	week	5	6	9
end of sale	week	7	8	12
duration of crop	weeks	28	29	33
plants/m²	start>end	62>34	62>34	62>34
area net	m² x days	4442	4452	5292
amount for sale	pots	1000	1000	1000
selling rate at the market	in %	95	95	95
revenue	**€**	**1140**	**1140**	**1140**
oil	litre	839	903	1083
oil costs	€	420	451	542
seeds and plants				
seedlings	unit	1050	1050	1050
price	€/unit	0.10	0.10	0.10
costs of seedlings	€	105	105	105
pots and substrates				
size of pots		10 cm	10 cm	10 cm
number of pots	units	1050	1050	1050
costs of pots	€	32	32	32
amount of substrate	litre	431	431	431
costs of substrate	€	20	20	20
fertilisation, plant protection				
water, fertiliser (low level)	€	7	7	9
plant protection (low level)	€	11	11	13
lighting	W/m²	50	50	
lighted area	m²	30	30	
lighting duration	h	1277	930	
costs of lighting	€	287	209	
selling				
package	units	125	125	125
costs of package	€	23	23	23
marketing charge	€	114	114	114
summary of direct costs	**€**	**1018**	**972**	**857**
manpower	hours	12.6	12.8	13.2
costs of manpower	€	89	89	93
output without direct costs	€	122	168	283
- per hour manpower	€/hour	10	13	21
- per area	€/1000 m² x days	29	38	54
net margin	**€**	**34**	**79**	**190**

Table 12: Economic calculations, examples 7 to 9

Examples		**7** 20 h 3000lx	**8** 80 klxh	**9** ambient daylight
start	week	32	32	32
start of sale	week	3	4	7
end of sale	week	5	6	10
duration of crop	weeks	26	27	31
plants/m²	start>end	62>34	62>34	62>34
area net	m² x days	3822	4032	4872
amount for sale	pots	1000	1000	1000
selling rate at the market	in %	95	95	95
revenue	**€**	**1235**	**1235**	**1235**
oil	litre	713	778	996
oil costs	€	357	389	498
seeds and plants				
seedlings	unit	1050	1050	1050
price	€/unit	0.25	0.25	0.25
costs of seedlings	€	263	263	263
pots and substrates				
size of pots		10 cm	10 cm	10 cm
number of pots	units	1050	1050	1050
costs of pots	€	32	32	32
amount of substrate	litre	431	431	431
costs of substrate	€	20	20	20
fertilisation, plant protection				
water, fertiliser (low level)	€	6	7	8
plant protection (low level)	€	10	10	12
lighting	W/m²	50	50	
lighted area	m²	30	30	
lighting duration	h	1030	840	
costs of lighting	€	232	189	
selling				
package	units	125	125	125
costs of package	€	23	23	23
marketing charge	€	124	124	124
summary of direct costs	**€**	**1064**	**1055**	**997**
manpower	hours	12.4	12.5	13.0
costs of manpower	€	87	88	91
output without direct costs	€	171	180	256
- per hour manpower	€/hour	14	14	20
- per area	€/1000 m² x days	45	45	53
net margin	**€**	**84**	**92**	**165**

4.0 Conclusions

From the 34 plant species / varieties tested during this year's early spring trial (2006/2007) at Dresden-Pillnitz 25 species were suitable for cultivation as early spring pot plants. The results of the research project give detailed information about the requirements for successful production such as vernalisation and reaction to different lighting treatments.

A selling date of Valentine's Day was achievable for most species when supplementary light was used. Supplementary lighting not only advanced the crop but it also improved plant quality. Some species like Papaver and calceolaria only flowered with photoperiodic or supplementary lighting. The quantity of light should be at least 80 klxh per day during the forcing treatment. However, there are plant species which were able to flower at Valentine's Day when exposed to photoperiodic light or even ambient daylight (provided the right pre-cultivation measures had been undertaken in terms of developing a plant of sufficient size prior to forcing and the appropriate vernalisation treatment). These species included: *Ajuga reptans* 'Mini Mahagoni', *Androsace septentrionalis* 'Star Dust', *Aquilegia* hybrida 'F1 Spring Magic' series, *Erysimum perovskianum* 'Goldrush', *Geum coccineum* 'Cooky', *Lindernia* 'Grandiflora' and *Phlox divaricata*.

The use of growth regulators like Topflor and CCC 720 to control plant habit and growth was possible using the correct application rate / frequency. Each species reacted differently to the growth regulators and the response was also governed by the developmental stage of the plant and the forcing conditions the plants were exposed to. There are still further questions to address about the use of growth regulators in sequential / combination treatments and the best time for applications.

There was a need for sufficient vernalisation before the forcing treatments commenced otherwise fewer flowers were produced, the flower stems did not elongate adequately above leaves, plant quality suffered and the period of forcing was extended. High temperatures during the storage period in the autumn and early winter can become a problem for successful growing (when using polythene tunnels or cold glasshouses). The early spring trials (2006/2007) in Dresden-Pillnitz and STC (UK) were strongly influenced by the high temperatures during storage 2006. A recommendation for future work on early spring pot plants could be the use of cold stores to satisfy the vernalisation requirement of the plants.

The changing climatic conditions in terms of temperatures and light quantity from year to year can make it difficult to schedule the crop to an exact selling date under ambient conditions. However, the trial has shown with adapted temperatures and supplementary lighting, crop scheduling is possible.

The cultivation of early spring pot plants can take place between other traditional crops. Pre-cultivation is possible outdoors, the storage stage can occur in frost-free glasshouse or in a polythene tunnel whilst the forcing period begins relatively late in the year, after for instance poinsettia production and prior to bedding plant production.

The cultivation costs of the early spring pot plants rose in the same way like most other horticultural crops during 2006/07 as the energy costs increased. The actual profitability of the crop depends very much on the individual situation of each business. If supplementary lighting is available on site then the crop fits well between other crops to maximise the use of this asset, if the costs of supplementary lighting can be offset against more crops through the year then the more profitable its use becomes. Early spring pot plants can realize higher prices than those traditionally achieved for primrose and pansy crops. This provides a new potential opportunity / revenue stream for growers during February and early March.

The plant species examined in the trial have high aesthetical value and good shelf life under living room conditions. Most species are perennials and have natural frost hardiness. However, with the early start of forcing the species become sensitive to frost. This is an important consideration. It is not recommended to use the term 'perennial' as an extra 'bonus' for selling. It is better to present the 'new' species as a new range of indoor pot plants. There is still however, a possibility that customers can keep the species in a light and cool place and then transfer the plants to the garden later in the year when the risk of severe frosts has reduced.

5.0 Technology Transfer

A presentation was made by Ute Hoffman at the BPOA (formerly BBPA) AGM on Thursday 8 February 2007 summarising the available results from the 2006/07 trial.

A further presentation is planned for February 2008.

HDC article in December 2006 / January 2007 HDC News entitled ‘Forcing for a price premium’.

6.0 Glossary

Net margin - gross margin less direct labour and machinery cost.

Vernalisation - the cold period required by certain plant species to hasten or induce flower initiation.

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8.0 Appendices

8.1 Content of the annex on the CD

Data files	sheets	contents
UKprojektdatenEndboni020407.xls	3……….F23	data of single varieties
UKDatenEndboni020407.xls	all data	combined data of all varieties
Bigtable06-07PC267.xls	with pgr	Overview of the number of plants and average values for all variants of the species with pgr treatments
	no pgr	Overview of the number of plants and average values for all variants of the species without pgr treatments
Fruehjahr.ab3		ULEAD PhotoImpact album of all picture with the option of automatic search (needs special ULEAD software)
LightUKPC267.xls	Diag2	diagram: amount of light in klxh
	evaluations	Light summaries of the different treatments in klxh
	burning time lamps	glasshouse compartments and the real lamp use per day
	Diag mol m^2	diagram: sum of PAR mol/m^2
	mol m^2	data
TemperaturesUKPC267.xls	temp storage	temperature during storage
	temp humidity	temperature and air humidity during forcing period
	average temp per day	real average temperature during forcing period
	wm	accumulated heating energy per glasshouse in MWh
Stockbridge170507.ppt		Powerpoint presentation from the meeting at stockbridge, May 17th2007
Report PC 267.doc		this technical report as pdf file

8.2 Germination and cropping details of the early spring trial 2006/2007

Nr.	UK No	species	variety	source	amount	**prop-week**	**Sow week**	germ-date	pr-date	**pr-week**	pr-amount	po-date	**po-week**	po-amount	**trim - week**
3		*Ajuga pyramidalis*	'Metallica Crispa'	Jal	100	**27**						31	**31**	99	
4		*Ajuga reptans*	'Braun Hertz'	Jal	100	**27**						31	**31**	112	
5	1	*Ajuga reptans*	'Mini Mahagoni'	Jal	500	**27**						34	**34**	539	
6		*Arabis ferdinandi*	'Coburgii Variegata'	Jal	115	**27**						34	**34**	94	
7	2	*Arabis ferdinandi*	'Old Gold'	Jal	100	**27**						34	**34**	84	
10	3	*Cymbalaria*	'Muralis'	Jal	100	**27**						34	**34**	99	**45**
13	4	*Iberis*	'Snow Flake'	Jal	500	**27**						12.9.06	**37**	486	**45**
14	5	*Lindernia*	'Grandiflora'	Jal	100	**27**						31	**31**	114	
15	6	*Lithodora*	'Heavenly Blue'	Jal	500	**27**						20.9.06	**38**	427	**45**
16		*Lithodora*	'Pete's Favorite'	Jal	100	**27**						20.9.06	**38**	50	**45**
20	7	*Serissa foetida*	'Pink Mystic'	Jal	100	**27**						31	**31**	99	
F 01	14	*Anacyclus pyrethrum var. depressus*	'Silberkissen'	Je	2 g		**29**	27.7.06	1.8.06	**31**	770	4.9.06	**36**	763	
F 02	12	*Andosace septentrionalis*	'Star Dust'	LfL			**29**	27.7.06	4.8.06	**31**	770	4.9.06	**36**	760	
F 03	18	*Aquilegia hybrida*	'Spring Magic Blue-White'	Be	1000		**29**	31.7.06	15.8.06	**33**	616	12.9.06	**37**	598	
F 04		*Aquilegia hybrida*	'Spring Magic Light red yellow'	Be	1000		**29**	31.7.06	16.8.06	**33**	770	5.9.06	**36**	756	
F 05		*Aquilegia hybrida*	'Spring Magic Light red-white'	Be	1000		**29**	31.7.06	14.8.06	**33**	770	5.9.06	**36**	765	
F 06		*Aquilegia hybrida*	'Spring Magic Navy-White'	Be	1000		**29**	28.7.06	10.8.06	**32**	770	5.9.06	**36**	762	
F 07		*Aquilegia hybrida*	'Spring Magic Pink-White'	Be	1000		**29**	31.7.06	15.8.06	**33**	770	11.9.06	**37**	765	
F 08		*Aquilegia hybrida*	'Spring Magic White'	Be	1000		**29**	31.7.06	15.8.06	**33**	770	11.9.06	**37**	763	
F 09	11	*Aquilegia vulgaris*	'Winky Double White-White'	Kieft	300		**29**	27.7.06	16.8.06	**33**	231	11.9.06	**37**	239	
F 11	8	*Barbarea rupicola*	'Sunnyola'	Kieft	1500		**29**	31.7.06	14.8.06	**33**	616	5.9.06	**36**	616	
F 12		*Calceolaria biflora*	'Goldcup'	Kieft	2000		**29**	27.7.06	16.8.06	**33**	770	11.9.06	**37**	766	
F 13	10	*Erigeron karvinskianus*	'Stallone'	Kieft	2000		**29**	27.7.06	15.8.06	**33**	770	5.9.06	**36**	763	**45**

Nr.	UK No	species	variety	source	amount	**prop-week**	**Sow week**	germ-date	pr-date	**pr-week**	pr-amount	po-date	**po-week**	po-amount	**trim - week**
F 14		*Erinus alpinus*	'Dr. Hähnle'	Je	1 g		**29**	28.7.06	14.8.06	**33**	770	12.9.06	**37**	620	
F 15	9	*Erysimum perovskianum*	'Goldrush'	Kieft	2000		**29**	27.7.06	1.8.06	**31**	770	4.9.06	**36**	747	
F 16	17	*Geum coccineum*	'Cooky'	Be	1000		**29**	28.7.06	16.8.06	**33**	616	5.9.06	**36**	591	
F 17	15	*Horminum pyrenaicum*	'Rubrum'	Je	1 g		**29**	28.7.06	16.8.06	**33**	308	12.9.06	**37**	314	
F 18		*Horminum pyrenaicum*		Je	1 g		**29**	28.7.06	16.8.06	**33**	770	11.9.06	**37**	752	
F 19		*Lychnis alpina*		Je	1 g		**29**	27.7.06	15.8.06	**33**	770	12.9.06	**37**	695	
F 20	16	*Lychnis alpina*	'Snow Furry'	Je	1 g		**29**	28.7.06	11.8.06	**32**	770	12.9.06	**37**	714	
F 21	19	*Papaver miyabeanum*	'Pacino'	Be	0,5 g		**29**	31.7.06	16.8.06	**33**	770	12.9.06	**37**	709	
F 22	20	*Papaver nudicaule*	'Garden gnome'	Be	0,5 g		**29**	27.7.06	8.8.06	**32**	770	4.9.06	**36**	733	
F 23	13	*Silene pendula*		LfL			**29**	27.7.06	1.8.06	**31**	770	4.9.06	**36**	736	
24	21	*Phlox divaricata original*		bGD	400	**27**					432	5.9.06	**36**	408	**45**
26	21	*Phlox divaricata propagation*		bGD	400	**27**					415	5.9.06	**36**	486	
25		*Ajuga reptans Eigenv.*	'Mini Mahagoni'	LfL		**35**						20.9.06	**38**	598	

Pr-date – pricking out date
Pr-week – pricking out week
Pr-amount – pricking out amount
Po-date – potting on date
Po-week – potting on week
Po-amount – potting on amount
Trim-week – week of trimming