ANNUAL REPORT

To:
Horticultural Development Council
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IMPROVED SCHEDULING OF VIOLAS AND PANSIES THROUGH THE USE OF NIGHT-BREAK LIGHTING

PC 238

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June 2006

Commercial - In Confidence

Grower Summary

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Improved scheduling of violas and pansies through the use of night-break lighting

Annual Report 2006

Project title:	Improved scheduling of violas and pansies through the use of night-break lighting

Project number:	PC 238
Project leader:	Dr Steve Adams
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Key words:	Flowering, scheduling, daylength, photoperiod, night-break lighting, viola, *Viola cornuta*.

Signed on behalf of:	**Warwick HRI**
Signature:	…………………………………………………………
Name:	Professor Simon Bright Director and Head of Department
Date:	………………………………………………………….

The results and conclusions in this report are based on an investigation conducted over one year. The conditions under which the experiment was carried out and the results obtained have been reported with detail and 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.

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Headline

Daylength had little effect on the time of flowering of violas from the Sorbet and Butterfly series when treatments were applied after plugs were potted up. Therefore, the potential for using night-break lighting at this stage to improve crop scheduling is limited in this crop.

Background and expected deliverables

The flowering of modern varieties of pansy and viola using standard production methods leaves short, but important, gaps in the potential sales periods when the plants are of saleable size but have little or no flower. These gaps do not occur at the same time in all parts of the country as the sales periods are influenced by weather conditions. This shows the need for programmeability in this crop which will require the application of techniques already researched, but not yet commercially applied for the control of flowering.

While light integral appears to have the biggest impact on the time to flowering of pansies (Adams *et al*., 1997), the cost of supplementary lighting excludes its use as a tool for the commercial scheduling of pansies and violas. Similarly, temperature affects flowering time, but the potential to manipulate it to control flowering is limited as crops are grown cool to reduce energy costs and to maximise quality (Adams *et al*., 1996). While modern winter flowering pansies are sometimes assumed to be day-neutral, pansies have been shown in the past to be quantitative long-day plants (Hughes and Cockshull 1966; Adams *et al*., 1997; Runkle and Heins, 2003). This means that while they will flower under short days in winter, flowering is hastened under long-day conditions. While this has been known for some time it has not been exploited to any extent by the industry. Furthermore, there is little information on the response of violas to daylength.

Summary of the project and main conclusions

The effects of daylength on flowering time of violas were examined. Seeds from the Sorbet and Butterfly series (Table 1) were sown by a commercial propagator in weeks 31 and 33 for autumn and weeks 38, 40 and 42 for spring crops. When the plugs were marketable they were transported to Warwick HRI were they were potted up into 6 packs. Plants were grown-on to flowering in glasshouse compartments set to provide only frost protection.

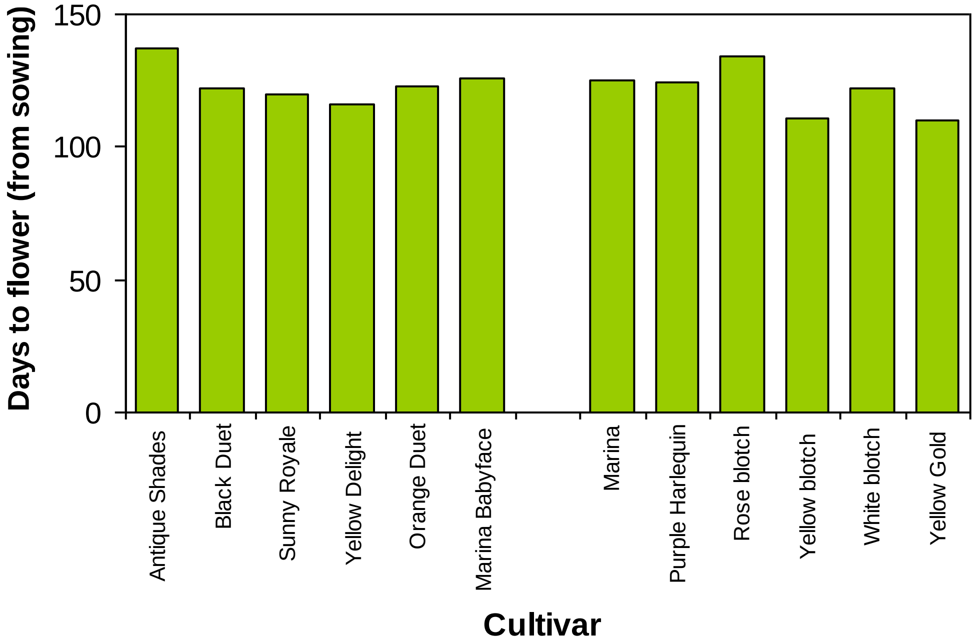
***Table 1**. The viola series/colours included in the trial.*

Sorbet™ Series from BallColegrave	Butterfly Series from Rudy Raes
Antique Shades	Marina
Black Duet	Purple Harlequin
Sunny Royale	Rose blotch
Yellow Delight	Yellow blotch
Orange Duet	White blotch
Marina Babyface	Yellow Gold

Although crops are unlikely to be grown under fixed daylengths commercially, an experiment using photoperiod chambers was used to quantify the flowering responses of the different cultivars to daylength. Two identical glasshouse compartments, each containing a suite of four photoperiod chambers, were used to provide daylengths of 8, 11, 14 and 17 hours. A second experiment compared a crop grown under a natural (changing) daylength with one where night-break lighting (10:30 to 01:30 GMT) was used to simulate long days. This was carried out to quantify the potential commercial benefits of manipulating daylength.

Photograph showing the plants on the photoperiod trolleys to the left and plants grown on the floor with night-break lighting to the right.

The biggest impact on the time to flower was the sowing date. As anticipated, the first two batches flowered quickly in time for the autumn market while the last three batches over-wintered and flowered in spring. As one might expect there were also cultivar differences within a series. Antique Shades and Rose Blotch tended to be later flowering whereas the yellow cultivars tended to flower first.



The effect of cultivar on time to flowering averaged across all batches.

Surprisingly, there was little evidence of any effects of photoperiod in either of the experiments. This was consistent across all of the cultivars examined suggesting that either viola are day-neutral or that the plants had already initiated flowers while in plugs. The first batch arrived with fairly large flower buds and plants started to flower shortly after transplanting and so it is perhaps not surprising that these plants did not show any response to daylength. However, the later batches did not have any obvious buds on arrival.

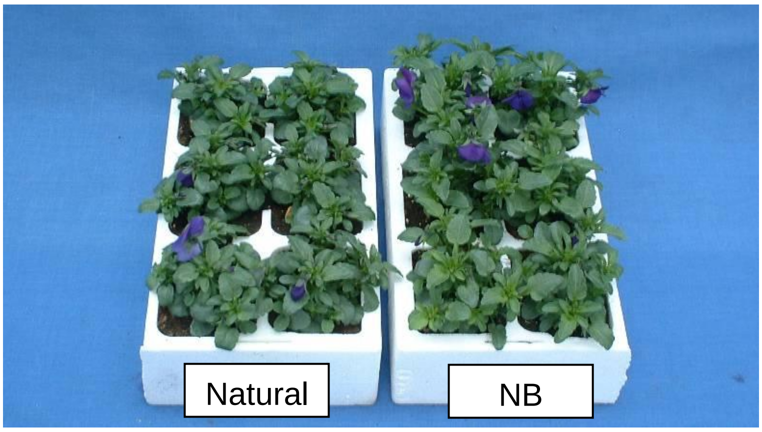
Sorbet Black Duet

Sorbet
Orange
Duet

Butterfly
Purple
Harlequin

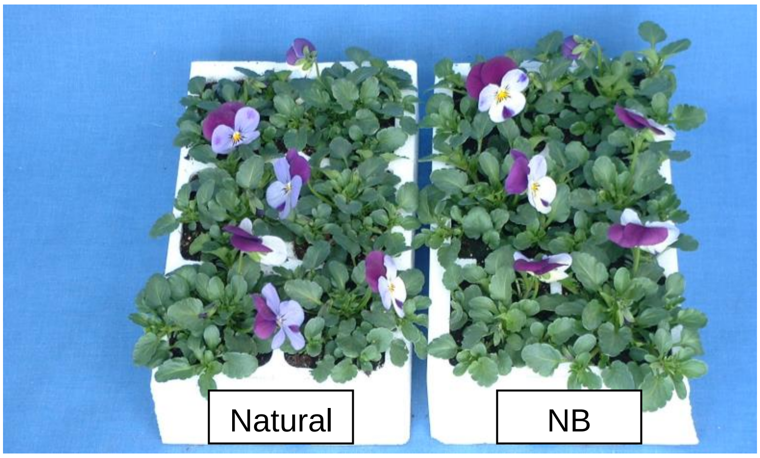
Butterfly
Rose blotch

Photographs showing the effects of the fixed daylength treatments on four selected cultivars (sown week 40). Additional cultivars can be seen in the main report.



Sorbet
Black
Duet

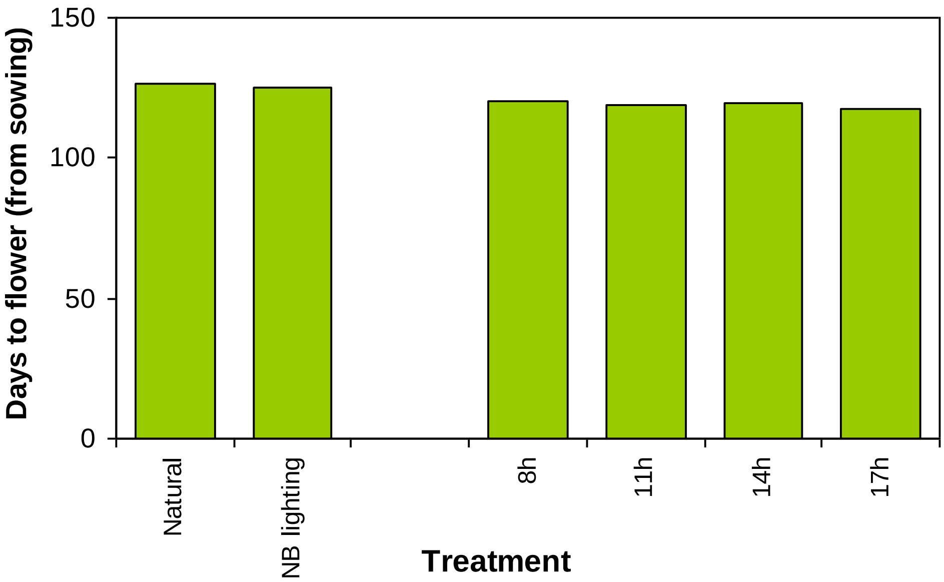
Sorbet Orange Duet



Butterfly Purple Harlequin

Butterfly Rose blotch

Photographs showing the effects of the night-break lighting on four selected cultivars (sown week 40). Additional cultivars can be seen in the main report.



The effect of daylength on

time to flowering averaged across all batches and cultivars.

When packs were at the marketable stage (at least one open flower per plant), three plants of Sorbet Yellow Delight and three plants of Butterfly Yellow blotch were sampled from each pack to record plant quality. There was no significant effect of the long-day or night-break lighting treatments on shoot fresh weight. While, for these cultivars, there was no significant difference in the height of the plants grown on under different fixed daylengths, the plants grown on the floor with night-break lighting were around 0.8cm taller than those grown under a natural daylength, despite the fact that compact fluorescent lamps were used. Having reached the marketable stage, packs were left for a further two weeks and the number of open flowers per pack were recorded. However, the impact of daylengthon flowering was negligible.

Financial benefits

This report only covers the first experiment of a two year project and so it is too early to make clear recommendations or calculate financial benefits. However, it seems doubtful that night-break lighting post transplanting will prove to be a successful tool for the manipulation of flowering in violas.

Action points for growers

The results to date do not indicate the need to apply night-break lighting for the production of violas. We will examine the potential to use night-break lighting at the plug stage in year 2 and pansies will be included in this work.

SCIENCE SECTION

Introduction

The flowering of modern varieties of pansy and viola using standard production methods leaves short, but important, gaps in the potential sales periods when the plants are of saleable size but have little or no flower. These gaps do not occur at the same time in all parts of the country as the sales periods are influenced by weather conditions. For example, growers in the south east report a period in late October/early November when it is hard to produce a marketable product in flower, whereas growers further north appear to have greater difficulty in early spring. This shows the need for programmeability in this crop which will require the application of techniques already researched, but not yet commercially applied for the control of flowering.

While light integral appears to have the biggest impact on the time to flowering of pansies (Adams *et al*., 1997), the cost of supplementary lighting excludes its use as a tool for the commercial scheduling of pansies and violas. Similarly, temperature affects flowering time, but the potential to manipulate it to control flowering is limited as crops are grown cool to reduce energy costs and to maximise quality (Adams *et al*., 1996). While modern winter flowering pansies are sometimes assumed to be day-neutral, pansies have been shown in the past to be quantitative long-day plants (Hughes and Cockshull 1966; Adams *et al*., 1997; Runkle and Heins, 2003). This means that while they will flower under short days in winter, flowering is hastened under long-day conditions. While this has been known for some time it has not been exploited to any extent by the industry.

To enable the exploitation of long-day or night-break lighting, popular varieties need to be screened for their response to daylength. As small flowered violas are an increasing sector of the market we concentrated on this crop in year 1.

Materials and methods

This experiment examined the effects of daylength on the flowering time of violas. Two series were used, Sorbet and Butterfly, with six colours from each series (Table 1). Seeds were sown by a commercial propagator (W.J Findon & Son) into 216 trays which divide into quarters (cell size similar to a standard 240 tray). Seeds were sown in weeks 31 and 33 for autumn and weeks 38, 40 and 42 for spring crops (Table 2). When the plugs were marketable they were transported to Warwick HRI where they were potted up into polystyrene 6 packs containing Vapogro Autumn Bedding compost (100% peat, pH of 5.5, wetting agents, P.G. Mix 14-16-18 @1.5Kg/m3 and Ironite @1.5Kg/m3). Plants were watered overhead as necessary. After the first 3 weeks following potting up liquid feed using potassium nitrate was provided approximately weekly (weather dependent) at a rate of 1g/l. Plants were grown-on to flowering in glasshouse compartments set to provide only frost protection (heating set point 3°C, venting at 5°C).

Experimental treatments

<u>Experiment 1 – fixed daylengths</u>

Although crops are unlikely to be grown commercially under fixed daylengths, an experiment using photoperiod chambers was used to quantify the flowering responses of the different cultivars to daylength. Two identical glasshouse compartments containing suites of four photoperiod chambers were used. Plants were grown on automated trolleys (1.7m^2) which receive natural daylight for 8 hours per day. At 16:00 h (GMT) each day the trolleys were moved into the light-tight chambers where they remained until 08:00 h the following day. Long days were provided with low intensity day-extension lighting (~3.5 µmol/m^2/s) using fluorescent lamps. The facility was used to provide daylengths of 8, 11, 14 and 17 hours (see appendix 1 for an experimental plan). As long days were provided with low intensity lighting, all these treatments received a similar light integral. The chambers were ventilated at night to minimise any temperature lift due to the lamps. There was one pack of each colour/batch on each trolley with two replicate trolleys (one in each glasshouse compartment) for any given photoperiod treatment.

***Table 1**. The viola series/colours included in the trial.*

Sorbet™ Series from BallColegrave		Butterfly Series from Rudy Raes	
	Antique Shades		Marina
	Black Duet		Purple Harlequin
	Sunny Royale		Rose blotch
	Yellow Delight		Yellow blotch
	Orange Duet		White blotch
	Marina Babyface		Yellow Gold

Table 2. *Dates when batches of plants were sown by W.J. Findon & Son and when they were judged to be marketable and were taken to Warwick HRI.*

Batch	Sowing		Transplanting/start of treatments	
	Week	Date	Week	Date
1	31	3 Aug	36	7 Sept
2	33	17 Aug	37	12 Sept
3	38	21 Sept	42	21 Oct
4	40	5 Oct	45	10 Nov
5	42	19 Oct	47	24 Nov

Experiment 2 – natural daylengths and night-break lighting

A second experiment compared a crop grown under a natural (changing) daylength with one where night-break lighting was used to simulate long days. This was carried out to quantify the potential commercial benefits of manipulating daylength.

Plants were grown on the floor in the two glasshouse compartments used for experiment 1. In one compartment plants were grown under a natural daylength, while in the other compartment a three hour night-break lighting treatment (10:30 to 01:30 GMT) was applied using compact florescent lamps (~2.5 µmol/m^2/s). In order to avoid light pollution from the lit treatment the two glasshouse compartments were not adjacent. There were 4 replicate packs per treatment combination.

Plant and environmental records

The day that the first flower of each plant opened was recorded. When packs were marketable (at least one open flower per plant), three plants of Sorbet™ Yellow Delight and three plants of Butterfly Yellow blotch were sampled per pack to record plant quality (shoot fresh weight and plant height). The remaining plants were left for a further two weeks and the numbers of open flowers per pack were recorded to indicate whether the treatments affected flower numbers.

Environmental data were recorded via the climate computer (Priva Integro) and a number of independent sensors linked to Orchestrator software and data-loggers (DL2, Delta-T Devices Ltd). Light sensors (quantum sensors and Kipp Solarimeters) were positioned in the compartments including below the night-break lighting treatment.

Figure 1. *Photograph of the experimental facilities showing the layout of the experiment with the plants on the photoperiod trolleys to the left and plants grown on the floor with night-break lighting to the right (see appendix 1 for an experimental plan).*

P&D control and physiological disorders

Plants were sprayed with Alliete (5g/l) and Amistar (1ml/l) after transplanting as a preventative for Downy mildew. Due to some caterpillar damage, Decis was applied (1ml/l) in September. Some colours (particularly Butterfly Marina and to a slightly lesser extent Sorbet Antique Shades) developed black spot and so a spray programme involving Bavistin (0.5g/l) and Amistar (1ml/l) was used. *Amblyseius cucumeris* was introduced regularly as a precaution against thrips and *Hypoaspis miles* was introduced in spring for the control of sciarid flies.

Some plants from the second batch (which were sown on 3 August and transplanted on 7 September) showed leaf distortion and mottling (Figure 2). The problem first appeared soon after transplanting and gradually worsened, eventually affecting 15% of the plants from this batch. The other batches were unaffected despite having been treated in the same way; this suggests that there might have been an environmental trigger. Furthermore, the problem was clearly cultivar related as it affected 46% of

Sorbet Sunny Royale, while none of the Butterfly Yellow blotch plants were affected. Tests did not reveal the presence of any virus. Damaged plants were excluded from subsequent analyses.

Figure 2. *Photographs showing plants from the second batch with distortion and mottling.*

The third batch of plants showed symptoms comparable to that of having been sprayed with a growth regulator, the effect persisted throughout the trial. Plants were very stunted and so caution is needed in interpreting the data from this batch.

Results

Environmental conditions achieved

The environments of two glasshouse compartments were very similar. The average temperature over the course of the whole experiment was 11.1°C and the relative humidity averaged 70%. Due to external conditions the glasshouse temperatures decreased through autumn into winter and then began to increase again towards the end of the experiment, Spring 2006 (Figure 3). The changes in light levels (PPFD) and natural daylength over the course of the experiment are shown in Figure 4.

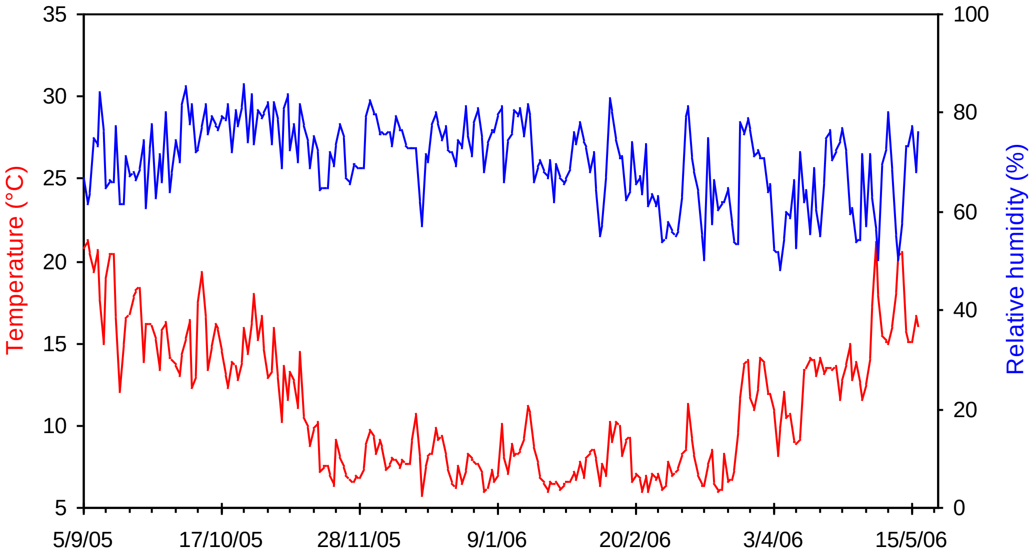


Figure 3. *Mean diurnal values of air temperature and relative humidity recorded in the experimental glasshouses over the course of the experiment.*

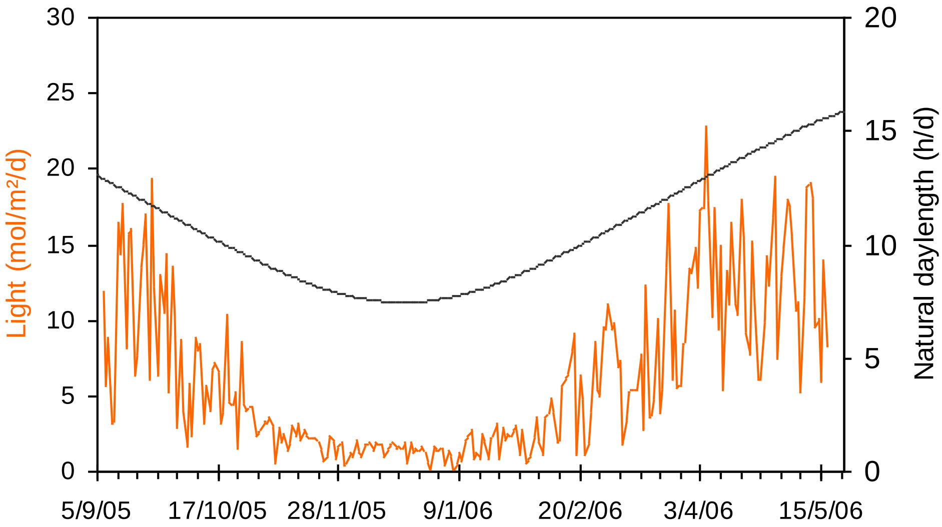


Figure 4. *Daily light levels (PPFD from sunrise to sunset) measured at plant height in the night-break lighting treatment together with the natural photoperiod which the plants without night-break lighting would have experienced.*

Flowering time

The biggest impact on the flowering time (time from sowing to first open flower) was the sowing date (P<0.001). As anticipated, the first two batches flowered quickly in time for the autumn market while the last three batches over-wintered and flowered in spring (Figure 5). The flowering of the plants sown in week 38 may have been slightly delayed due to the fact that growth was stunted, presumably due to the application of a growth regulator.

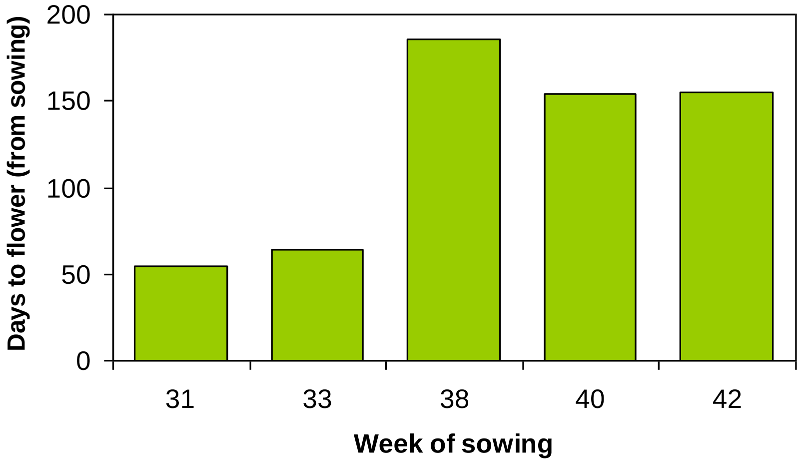


Figure 5. *The effect of sowing date on time to flowering averaged across all cultivars (SED = 0.511; 629 d.f.).*

As one might expect there were also cultivar differences within a series ($P<0.001$). Antique Shades and Rose Blotch tended to be later flowering whereas the yellow cultivars tended to flower first (Figure 6).

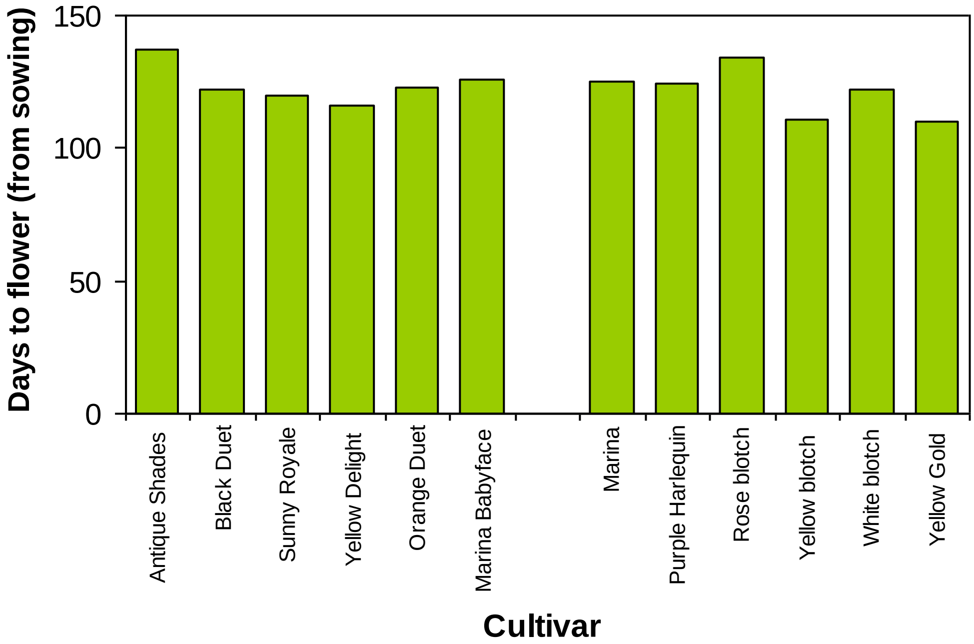


Figure 6. *The effect of cultivar on time to flowering averaged across all batches (SED = 0.792; 629 d.f.).*

There was no significant difference ($P>0.05$) in the flowering time between the two compartments which is reassuring in that it indicates that the compartments and the achieved environment were indeed identical. However, there were difference in the flowering time of the two experiments; the autumn crops tended to flower around 10 days later when grown on the floor (experiment 2) when compared with those grown on the photoperiod trolleys (experiment 1) ($P<0.001$).

Surprisingly, there was little evidence of any effects of photoperiod in either of the experiments (Figure 7-9). This was consistent across all of the cultivars examined suggesting that either all of the cultivars are day-neutral with regards to this flowering response to daylength or that the plants had already initiated flowers while in plugs. The first batch arrived with fairly large flower buds and plants started to flower shortly after transplanting and so it is perhaps not surprising that these plants did not show any response to daylength. The latter batches did not have any obvious buds on arrival, although we should not preclude the possibility that they were already committed to flowering.

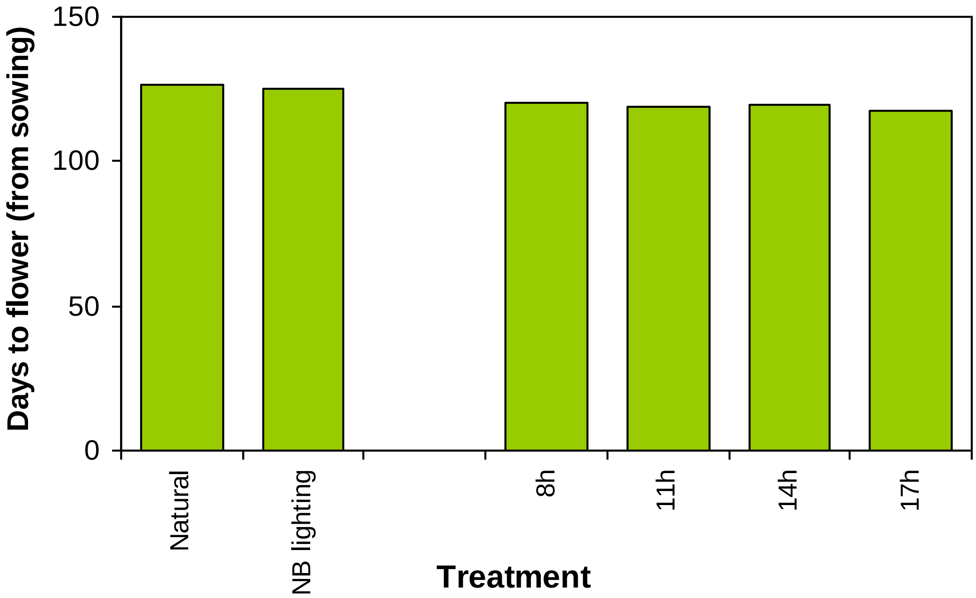
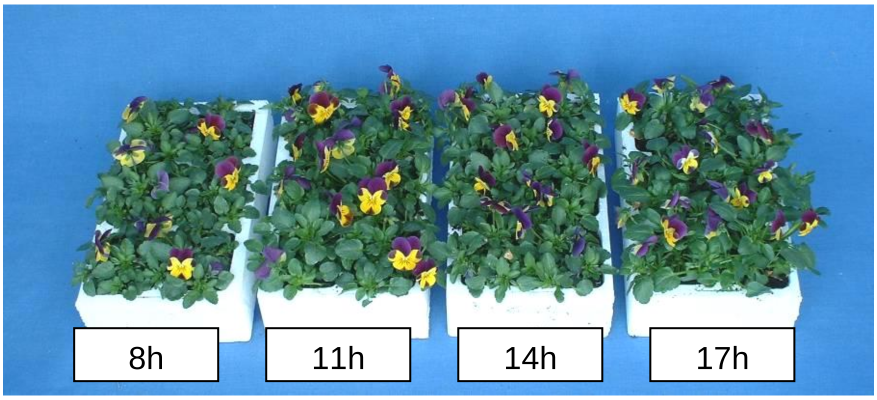


Figure 7. *The effect of daylength on time to flowering averaged across all batches and cultivars (SED for comparison of natural vs NB = 0.378; 117 d.f., SED for comparison of fixed photoperiods = 0.705; 228 d.f.).*

Figure 8. *Photographs showing the effects of the fixed daylength treatments (sown week 40).*

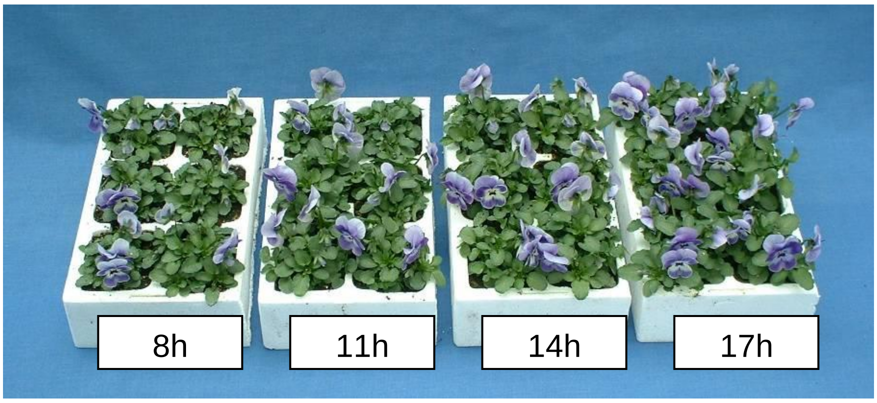
Sorbet
Antique
Shades

Sorbet
Black
Duet



Sorbet
Sunny
Royale

Sorbet
Orange
Duet



Sorbet
Marina
Babyface

Butterfly
Marina

Butterfly
Purple
Harlequin

Butterfly
Rose blotch

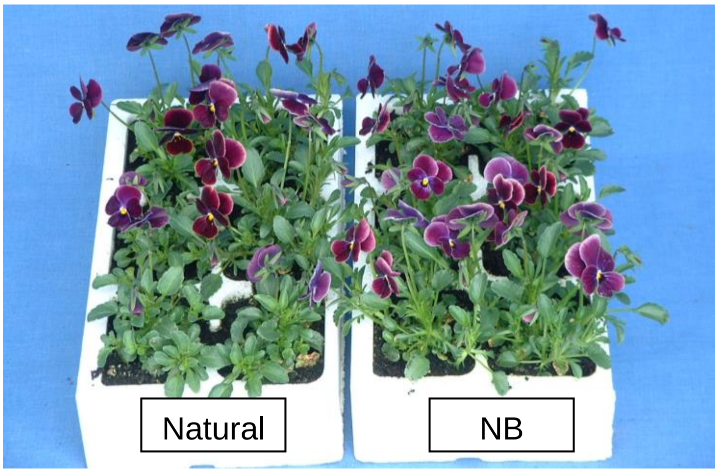
Butterfly

White blotch

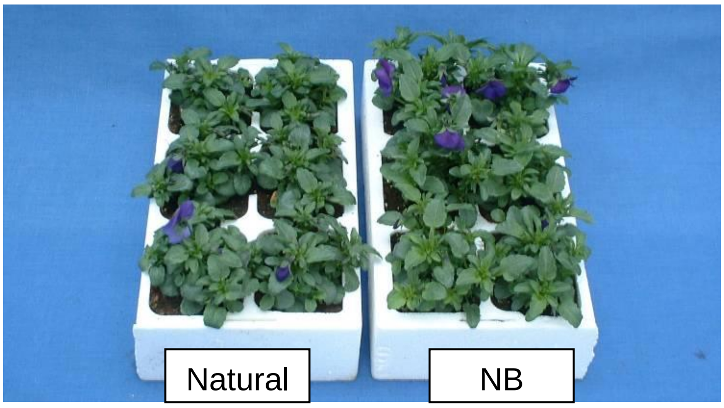
Butterfly

Yellow Gold

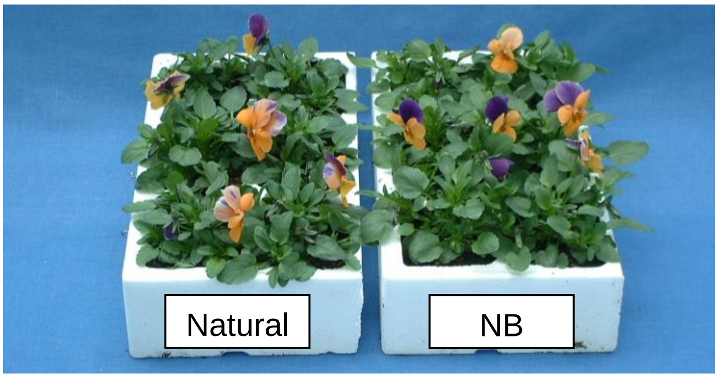
Figure 9. *Photographs showing the effects of the night-break lighting (sown week 40).*



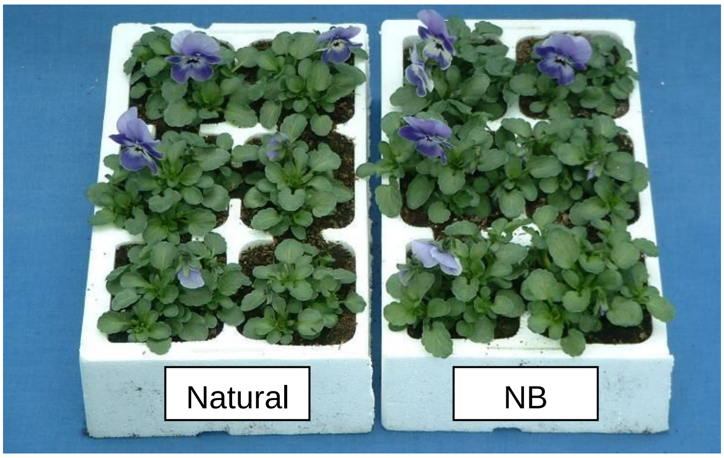
Sorbet
Antique
Shades



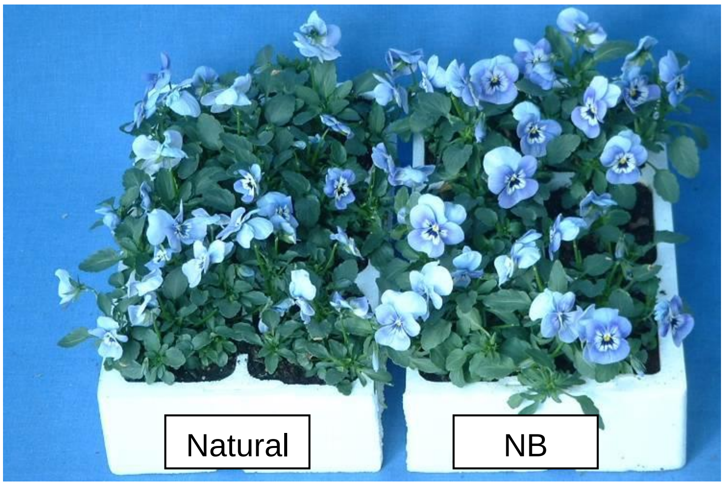
Sorbet
Black
Duet



Sorbet
Orange
Duet



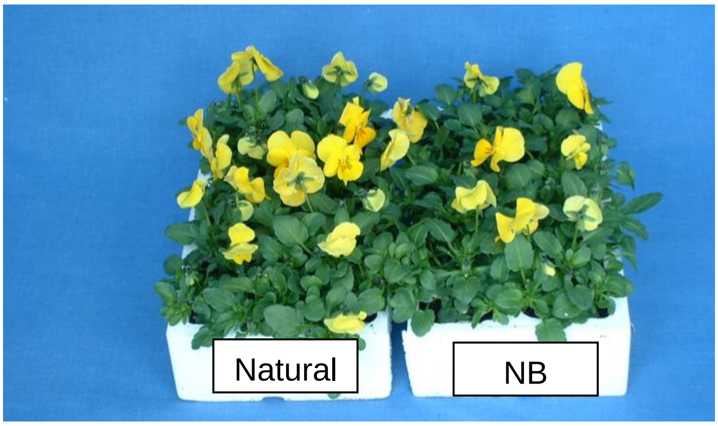
Sorbet
Marina
Babyface



Butterfly
Marina

Butterfly
Purple
Harlequin

Butterfly
Rose blotch



Butterfly
Yellow Gold

Plant fresh weight and height

When packs were at the marketable stage (at least one open flower per plant), three plants of Sorbet Yellow Delight and three plants of Butterfly Yellow blotch were sampled from each pack to record plant quality (shoot fresh weight and plant height). There was no significant effect of the long-day or night-break lighting treatments on fresh weight (*P*>0.05). As with flowering time, the main differences were due to sowing date (batch) and cultivar (*P*<0.001). Yellow Delight tended to have more bulk, the one exception being batch 3 (week 38) where plants were affected by growth regulator (Figure 10). The plants from the first sowing date tended to be lighter as they flowered shortly after transplanting.

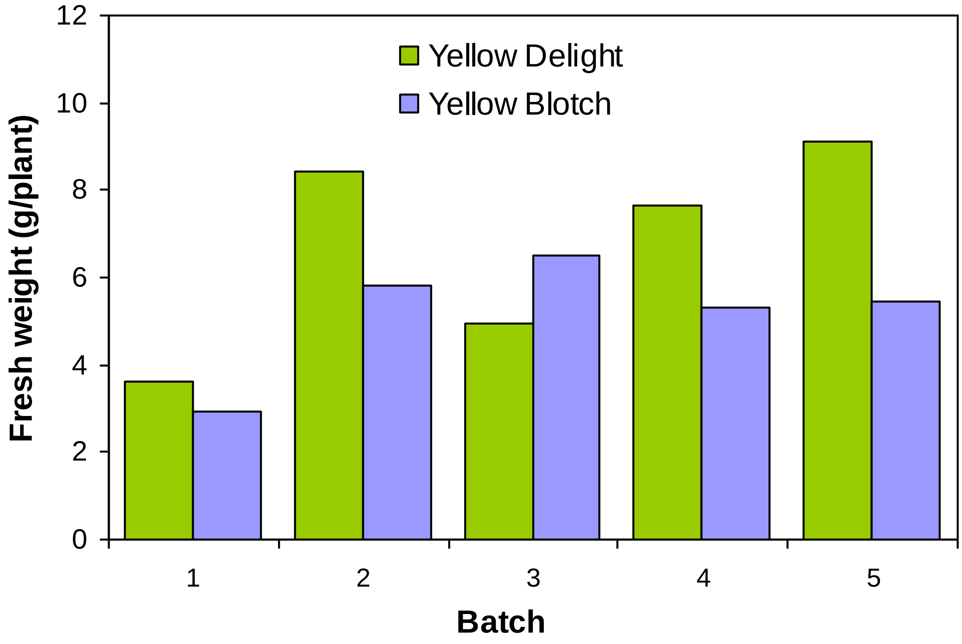


Figure 10. *The effect of sowing date (batch) and cultivar on the fresh weight of plants sampled when packs were marketable. The data are averaged across all of the daylength treatments (SED = 0.562; 80 d.f.).*

Plant height was also affected by batch and cultivar (*P*<0.001); Yellow Delight tended to be taller at marketing (Figure 11). While there was no significant difference (*P*>0.05) in the height of these cultivars grown on under different fixed daylengths (experiment 1), the plants grown on the floor with night-break lighting were significantly taller (*P*<0.01); they were around 0.8cm taller than those grown under a natural daylength, despite the fact that compact fluorescent lamps were used (Figure 12).

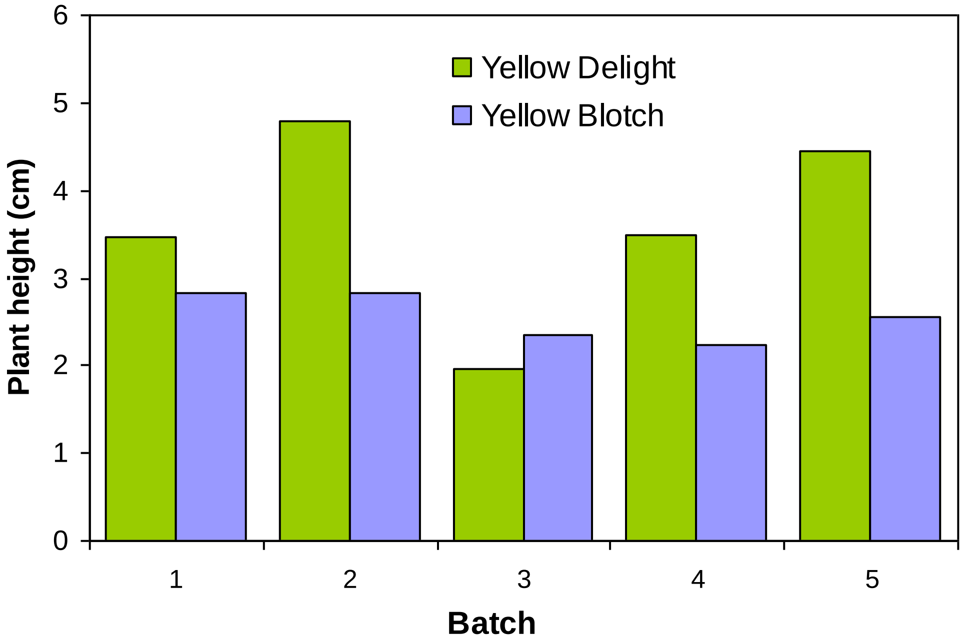


Figure 11. *The effect of sowing date (batch) and cultivar on plant height when packs were marketable. The data are averaged across all of the daylength treatments (SED = 2.228; 81 d.f.).*

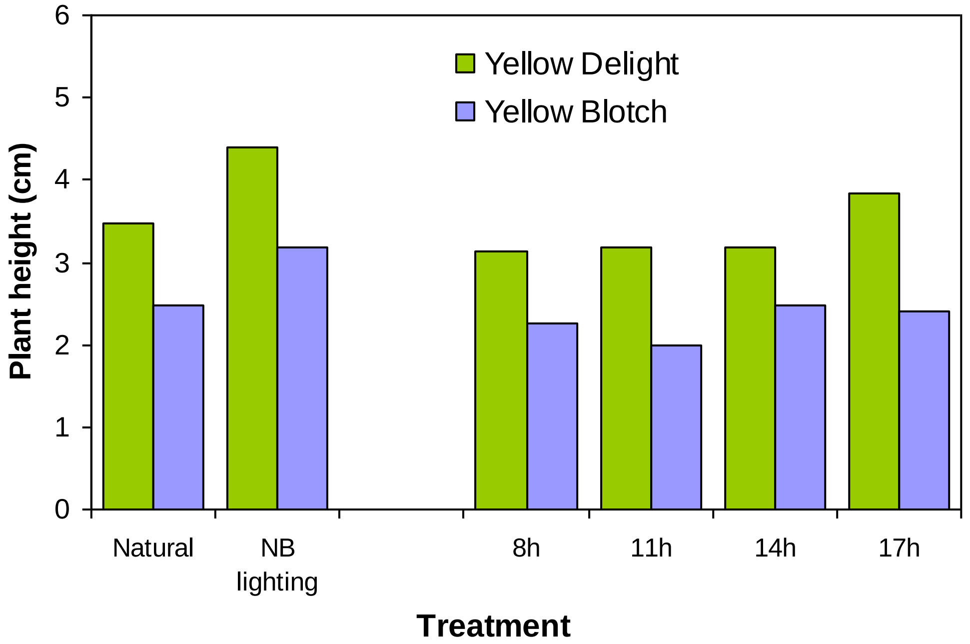


Figure 12. *The effect of daylength treatment on plant height when packs were marketable. The data are averaged across all of the batches (SED for comparison of natural vs NB = 2.932; 11 d.f., SED for comparison of fixed photoperiods = 2.867; 39 d.f.).*

Flower numbers

Having reached the marketable stage packs were left for a further two weeks and the number of open flowers per pack were recorded to indicate whether the treatments affected flower numbers.

There was a positive correlation (0.58) between the total number of flowers 2 weeks after marketing and the time to marketing. There were more flowers on the spring batches when compared with the autumn batches and more flowers on the later flowering cultivars (*P*<0.001). This probably reflects the fact that later flowering packs were more variable in their flowering time and so the time from the first to last flower opening was increased. Consequently, more flowers may have opened before marketing, rather than during the subsequent two weeks.

There was in fact a significant effect of fixed photoperiod on the number of flowers two weeks after marketing (*P*<0.01); the 17h photoperiod trolley had slightly more open and dead flowers. However, the biggest impact was between the two experiments (*P*<0.001). The plants grown on the floor as part of experiment 2 had more flowers that those grown on the trolleys in experiment 1 (Figure 13). However, again may have been due to marketing having been delayed by on average 5 days.

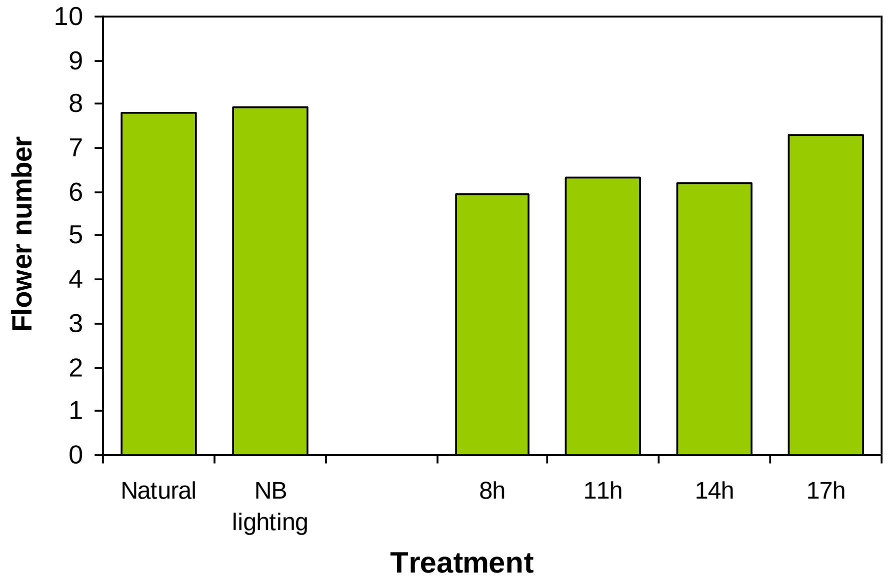


Figure 13. *The effect of daylength treatment on the average number of flowers (open and dead) per plant two weeks after packs were marketable. The data are averaged across all of the batches (SED for comparison of natural vs NB = 0.241; 115 d.f., SED for comparison of fixed photoperiods = 0.373; 225 d.f.).*

Discussion

Winter flowering pansies have been shown to be quantitative long day plants (Hughes and Cockshull 1966; Adams *et al.,* 1997; Runkle and Heins, 2003), despite being assumed by many to be day-neutral due to the fact that they flower over the winter when days are naturally short. However, there is little evidence to suggest that the viola series examined are long-day plants. It is possible that the lack of response was due to the fact that the plant material had already initiated flowers (or was committed to initiate) at the plug stage, before treatments commenced. This is quite likely for the first two batches which flowered in autumn (the first batch flowered soon after potting up) although less likely for the spring batches. If this is the case, daylength manipulation will have to be carried out by the plug producers. To confirm whether these plants are indeed day-neutral, daylength manipulation will need to start at an earlier stage.

A number of plant species have shown increased growth as a result of long-day lighting treatments (reviewed by Adams and Langton, 2005). However, under the light levels used in this experiment the viola cultivars did not shown any significant increase in fresh weight as a result of day-extension or night-break lighting. Fluorescent lamps were chosen for the lighting treatments to minimise the stretching that often occurs with tungsten lamps which have a lower red:far-red ratio. The plants given a night-break lighting treatment were slightly taller than those grown under a natural daylength, but the problem of stretching was minimal; there were no significant differences in height of the two recorded cultivars under the fixed photoperiod treatments.

Future work

The results tend to indicate that violas are insensitive to daylength. It will be important to confirm this in Year 2 by imposing photoperiod treatments at a much earlier stage. This will indicate whether there may be potential to manipulate daylength during plug production. It will also be important to include pansies in this experiment. While some cultivars are known to be long-day plants, there is no information on many important cultivars. Furthermore, more work is needed on pansies to enable the manipulation of photoperiod to be optimised.

Technology Transfer

HDC News Articles

- Feature article September 2006

Presentations

- Pansy and Viola Conference in October 2004

References

Adams SR, Langton FA. 2005. Photoperiod and plant growth: a review. Journal of Horticultural Science and Biotechnology 80: 2-10.

Adams SR, Pearson S, Hadley P. 1996. Modelling growth and development of pansy cv. Universal Violet in response to photo-thermal environment: Application for decision support and scheduling. *Acta Horticulturae* 417: 23-32.

Adams SR, Pearson S, Hadley P. 1997. The effects of temperature, photoperiod and light integral on the time to flowering of pansy cv. Universal Violet (*Viola x wittrockiana* Gams.). *Annals of Botany* 80: 107-112.

Hughes AP, Cockshull KE. 1966. Effects of night-break lighting on bedding plants. *Experimental Agriculture* 16: 44-52.

Runkle ES, Heins RD. 2003. Photocontrol of flowering and extension growth in the long-day plant pansy. *Journal of the American Society of Horticultural Science* 128: 479-485.

Appendix 1 – Experimental plan:

Compartment layout: