Grower Summary

PC 296

Protected ornamentals: assessing the suitability of energy saving bulbs for day extension and night break lighting

Annual 2010

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Project Number:	PC 296
Project Title:	Protected ornamentals: assessing the suitability of energy saving bulbs for day extension and night break lighting
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Contractor:	University of Warwick
Industry Representative:	Mr Colin Frampton Donaldsons Flowers Ltd,
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Headline

Given the phase out of tungsten lamps announced by Defra, growers currently using tungsten lamps to either delay or promote flowering will have to find replacements, work to date indicates that compact fluorescent lamps may not prove to be adequate replacements in all cases. Further work is planned to examine how LED lighting might best be used to control flowering on a commercial scale.

Background and expected deliverables

Photoperiodic lighting can be used to promote flowering in long-day plants (LDP) and to delay or prevent flowering in short-day plants (SDP). Tungsten (T) lamps have traditionally been used for this purpose as they are cheap to purchase and have a suitable light quality. However, Defra have announced that 'inefficient' tungsten lamps will be phased out over the period Jan 2008 to Dec 2011 and higher wattage lamps are already becoming difficult to obtain. Furthermore, there is a desire from some growers to move away from tungsten lamps to minimise stretching which can occur as a consequence of the light spectrum. Consequently, there is an urgent need to assess the suitability of alternative lamps.

Perhaps the most obvious alternative to tungsten lamps, at least in the short term, is compact fluorescent (CF) lamps. However, these have a different light spectrum and so care is needed if planning to make this switch. Compact fluorescent lamps are typically warm-white, and when compared with tungsten lamps, they have a higher output in the green and yellow portions of the spectrum, and very little far-red.

It should be borne in mind that lamps that are sold as '100W equivalent' may be equivalent to a 100 W tungsten lamps in terms of what the human eye perceives (lux), but they are not equivalent for plants. To give a similar output of photosynthetically active radiation (PAR), a 100 W tungsten bulb will probably have to be replaced by 30-35 W of compact fluorescent lighting and the configuration of lamps, including light output and reflector design will need to be considered. Consequently switching from tungsten to compact fluorescent lamps might not be straightforward, even if the light spectrum proves appropriate. Furthermore, whilst tungsten lamps can be cycled for energy saving (often halving the number of hours that they are 'on'), there are drawbacks to doing this with compact fluorescent lamps.

This project was therefore designed to examine the suitability of energy-saving lamps for daylength control by investigating flowering responses to light quality and quantity. The first part of the project, reported here, compared the use of tungsten and compact fluorescent lamps for a range of horticultural plant species to quantify responses in order to provide

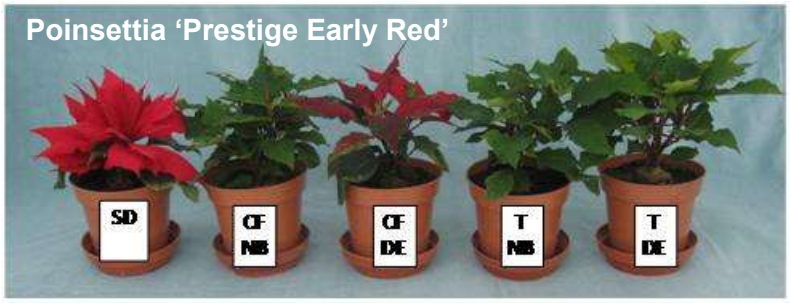
information towards making suitable recommendations for the replacement of tungsten lamps used to control photoperiod.

Summary of the project and main conclusions

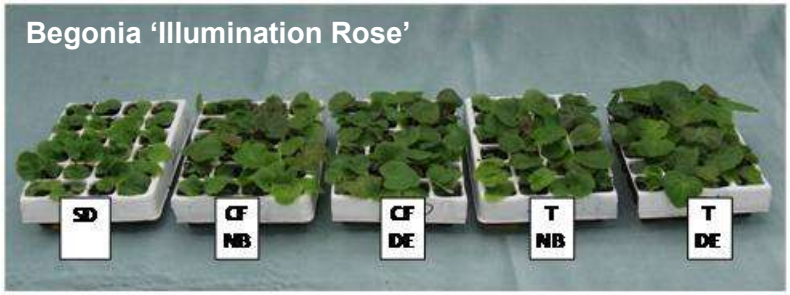
The effects of light level and light quality were examined in nine different species by growing plants in a suite of automated daylength controlled chambers (see photograph) where plants were exposed to 8 hours of daylight (from 08:00 h to 16:00 h) and then automatically transferred into light-tight chambers where the daylength was manipulated using tungsten or compact fluorescent lamps, or kept dark in the case of the short day treatment. Different light levels (1, 2.5 and 5 µmol/m^2/s) were used in the chambers. The effect of light level was also examined on fixed benches using light gradients (0.3 to around 9.3 µmol/m^2/s) to extend the natural short daylengths over winter. Both 8-hour day-extension lighting from 16:00 to 24:00 h, and 4-hour night-breaks (NB) from 22:00 h to 02:00 h were tested.

Chrysanthemum ('Tampico White'), plants grown under an 8-hour daylength (SD) budded and flowered rapidly (see photograph below), while all of the day extension (DE) and night break (NB) treatments remained vegetative until they had produced around 17-20 leaves on the side shoot; then they budded autonomously. Therefore, compact fluorescent (CF) lamps would appear to be safe for chrysanthemum. Interestingly even plants exposed to very low light levels (0.3 to 1 µmol/m^2/s) remained vegetative, suggesting that this cultivar might be more sensitive to light when compared with some of the older cultivars which were tested previously at the Glasshouse Crops Research Institute (GCRI).

Poinsettia (‘Prestige Early Red’) was also reasonably sensitive to compact fluorescent (CF) lamps. The plants grown under short days soon went red and had cyathia, while all of the long-day treatments initially remained green. Plants were kept for 26 weeks from pinching and over time some of the day extension (DE) and night break (NB) plants eventually showed some colour, although they did not develop fully red bract stars. There was considerable variability between plants, but colour was seen more frequently in the day extension (DE) treatment with compact fluorescent (CF) lamps. Plants appeared to be sensitive down to very low (0.3 µmol/m^2/s) light levels.

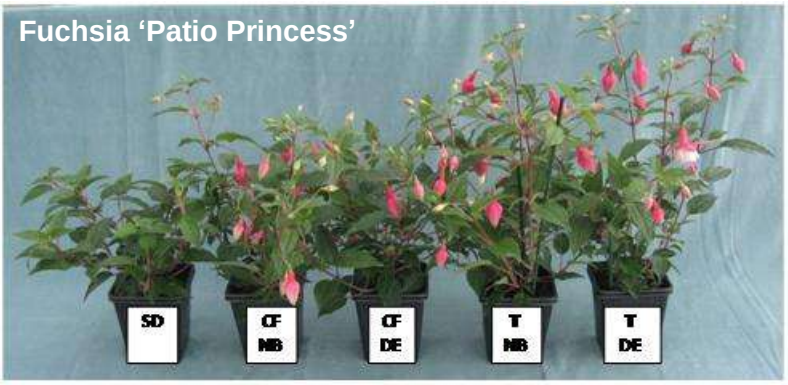


Non-stop begonia (‘Illumination Rose’) also responded well to compact fluorescent (CF) lamps, which were equally effective at delaying tuber formation and promoting shoot growth as tungsten (T) lamps. Plants appeared to be sensitive to very low (down to 0.3 µmol/m^2/s) light levels.

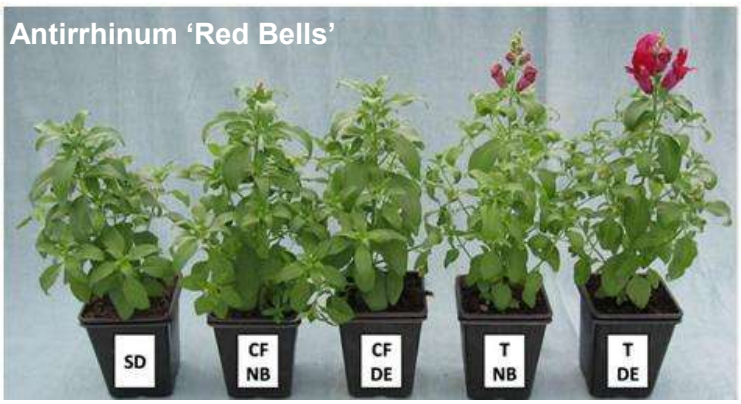


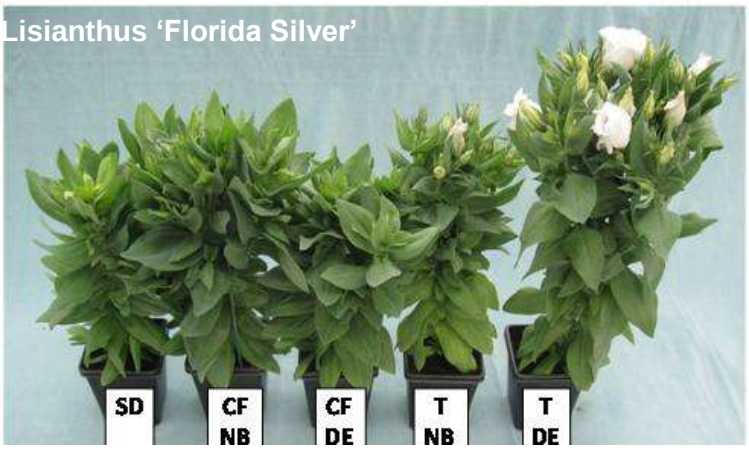
Christmas cactus (‘Olga’) was the only short day (SD) species tested where compact fluorescent (CF) lamps were less effective than tungsten (T) lamps. Flowering of these plants had been delayed by a tungsten (T) day extension (DE) treatment in commercial production before they were transferred to the experiments and this was also the most effective treatment for delaying flowering.

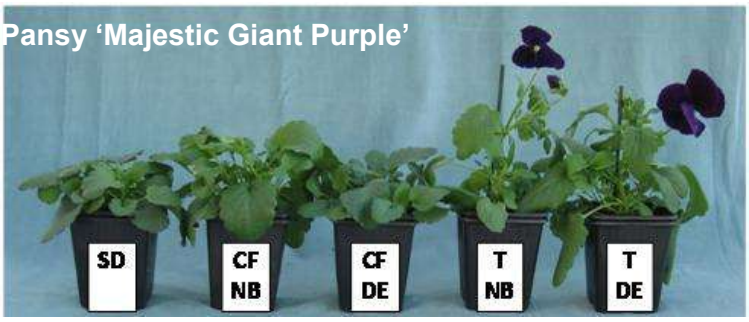
Fuchsia ('Patio Princess') plants grown under a continuous 8-hour daylength (i.e. SD) had no flower buds even at the end of the experiment (22 weeks after bud appearance in the long-day treatments) whereas the long day treatments budded rapidly. The day extension (DE) treatment with compact fluorescent (CF) lamps delayed flowering compared with the other long day treatments, but only by around 3 days. Plants appeared to be sensitive to very low (0.3 µmol/m^2/s) light levels.



Compact Fluorescent (CF) lamps tended to be less effective than tungsten (T) lamps for most of the long day plants that were tested. With **antirrhinum** ('Bells Red'), **lisianthus** ('Florida Silver' and 'Forever Blue') and **pansy** ('Majestic Giant Purple'), day extension (DE) lighting with compact fluorescent (CF) lamps proved ineffective, irrespective of the light level; plants flowered at a similar time to the short-day (SD) treatment. Night break (NB) lighting with compact fluorescent (CF) lamps was more effective, although it did not tend to hasten flowering as much as a tungsten (T) night break (NB). In the case of antirrhinum and lisianthus, plants budded sooner with an 8-hour tungsten (T) day extension (DE) than they did with a 4-h tungsten (T) night break (NB). Similar results were found across the light levels tested.



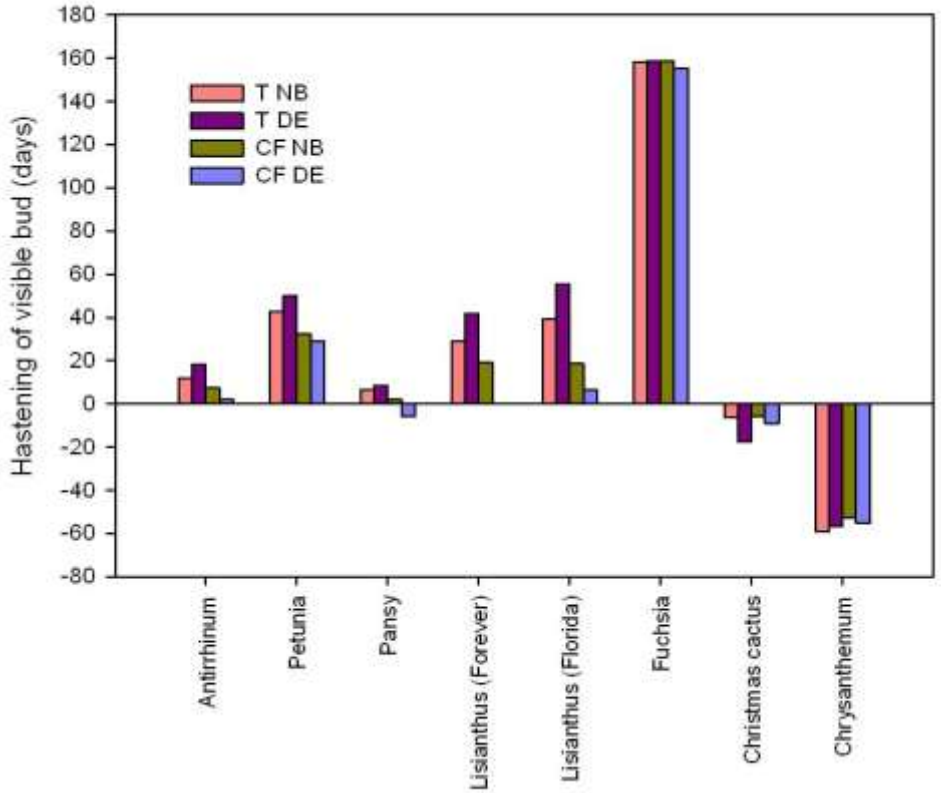




Day extension (DE) lighting with compact fluorescent (CF) lamps hastened flowering of **petunia** (‘Express Salmon’) when compared with the short day (SD) treatment. However,

once again, these lamps were not as effective as tungsten (T), especially when used as a day extension (DE). Similar results were found across the light levels tested.

A cautious approach should be taken with regards to the replacement of tungsten with compact fluorescent lamps as just over half of the species tested did not respond effectively to the light spectrum from compact fluorescent lamps. This can be illustrated for those species that could be assessed on time to flowering in the figure below. The data in this figure represents time of bud appearance relative to that of the short day treatment (i.e. hastening of flowering) for a range of species. Hence for antirrhinum, flowering was 12 days earlier as a result of tungsten (T) night break (NB) compared with plants grown in short days and the negative numbers (e.g. all Christmas cactus treatments) indicate where the lighting treatments delayed flower bud appearance.



These results applied even when the light level was increased to twice that of the current commercial norm. This is probably because the compact fluorescent (CF) lamps lack far-red light, which appears to be more important for day extension (DE) than night break (NB) lighting. Furthermore, while compact fluorescent (CF) lamps are a suitable replacement for tungsten (T) lamps in some species (e.g. chrysanthemum, poinsettia, fuchsia and begonias), there may be more efficient alternatives available soon.

Light–emitting diodes (LEDs) have advanced greatly and now provide a relatively efficient and robust alternative. They also have a much longer life expectancy than other lamp types, and this is not shortened by repeated cycling. While LEDs offer many advantages, high cost is currently an issue, although this is likely to come down over time. LED lamps can be manufactured to produce light of any given wavelength (colour), which is a big advantage for photoperiodic lighting if the plant requirements are known. The light output can be carefully selected to match the wavelengths that give optimal stimulation of plant light receptors.

Based on the results from this work, a combination of red (~660 nm) and far-red (~730 nm) light will probably give a good response for most species, although in some species, such as chrysanthemum, the far-red could be reduced, especially if stretching is a concern. The aim of subsequent experiments will be to test LED lamps of different wavelengths and compare their efficacy with tungsten lamps.

In summary the results suggest that compact fluorescent lamps could be safely used for chrysanthemums, poinsettias, fuchsia and begonias. However, with the other plant species tested more caution should be adopted as they did not respond to compact fluorescent lamps in the same way as they did with tungsten lamps. With Christmas cactus, a short day plant, a tungsten day extension was the most effective way of keeping plants vegetative. These plants had been kept vegetative prior to the start of the experiment using day extension lighting with tungsten lamps. Continuation of this treatment after the start of the experiment delayed bud appearance by a further 17 days (compared with the short day treatment). Whereas compact fluorescent lamps delayed bud appearance by 9 days (regardless of light level) when given as a day extension, and a compact fluorescent or tungsten night break delayed bud appearance by just 6 days. Therefore the phasing out of tungsten lamps could present a problem with this species.

Financial benefits

With tungsten lamps being phased out, growers face financial losses if they do not identify suitable alternatives. Taking Christmas cactus as an example, night break lighting is

currently used in the UK to extend the marketing window of finished product. If the lighting installed to replace exiting tungsten bulbs did not effectively delay the crop, there would be an estimated loss of sales of UK production worth around £123K before penalty clauses issued for loss of sales by the retailer (up to another £140K).

Growers using tungsten lighting will have to switch over to alternatives as the phase out progresses. The current costs for compact fluorescent lamps are around £5.00 to £6.00 each compared with £1.00 to £1.20 for a tungsten bulb. Replacement LED lamps would be estimated to cost £40 per lamp (for the Philips flowering lamps designed for photoperiod control). Clearly there are efficiencies in life of bulbs and also energy use that need to be traded off against these capital costs but the increase in bulb costs emphasises the importance of identifying not only which type of lamp will be effective for the specie(s) grown but also that the set up of bulbs (i.e. number required per unit area which is determined by desired intensity amongst other factors) is efficient. The next phase of work will include a comparison of lamp types based on their efficiencies as well as spectral outputs which will provide the baseline data growers will need to devise sensible lighting strategies.

Action points for growers

- Where replacing tungsten bulbs is urgent, growers should test the most favourable alternative compact fluorescent strategies on a small scale with their own mix of plant varieties before implementing changes.

- Ideally growers should start to evaluate future strategies based on the results reported here but they should also consider the follow up work planned for this project, which is to evaluate how LED lighting might fit in with their future plans for controlling photoperiod.