Project title:	**Investigation of the impact of temperature and light during the final phase of growth and an assessment of the interaction between marketing stage and shelf life.**
Report:	**Final Report (July 1998)**
Project Number:	**PC 71d**
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AUTHENTICATION

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

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1. PRACTICAL SECTION FOR GROWERS

Over recent years, HDC has funded trials at HRI Efford to study potential benefits of growing Poinsettia cool throughout production (HDC PC 71c; 1995-96). Data indicated that although many varieties could be produced using cooler regimes without compromising plant quality or shelf-life, the savings from reduced heating and plant growth regulator inputs had to be offset against significant delays of up to 3 weeks in production time. Amongst other things, the current trials aim to study how temperature can be used late in production to reduce crop delays whilst maintaining plant quality in 13C Poinsettias potted in week 31.

The specific objectives of the 1997 work were to:

- study the effect of manipulating temperature and light level post-initiation on plant quality and performance in shelf-life.

- investigate the effect of the stage of plant development at marketing on post-harvest performance, with the aim of defining the optimal marketing stage for each variety in terms of the physiological development rather than bract colour alone.

- provide valuable information on the performance of a range of new varieties produced under commercial conditions.

- study the impact of late-season application of a Propoxur smoke/Applaud programme for effective control of white fly infestations at or close to the marketing period.

▫ Temperature

In 1997 this work was developed to study the effects of starting crops under a standard temperature regime, and only reducing temperatures during the final phase of production, after initiation had occurred (from week 43 onwards). This tested the idea that plants might be able to take advantage of high light and favourable temperatures early on (to strengthen the stems), resulting in high quality plants without the severe delays which had been observed when using reduced temperatures throughout production. The trial compared plants grown at 15°C from week 43 (= cool-finished), with those finished at 18 or 21°C, with reciprocal transfers between 15 and 21°C in week 46.

Although the delays in production using 15°C from week 43 were much reduced when compared to the 1995-96 trials, there were still significant delays of 10 days associated with finishing production at 15°C compared to 18 or 21°C. Savings in use of plant growth regulators due to late-season cool-growing were minimal as most height control was achieved before week 43. The main savings would be due to reduced heating inputs. All temperature treatments produced plants of marketable

size, with cool-finished plants having smaller, more highly coloured bracts than in warm-finished plants. The effects of cool-finishing on bract size and colour may be desirable in varieties such as Freedom, which have characteristically large bracts.

The stage of cyathia development on a break was determined at marketing, by counting the numbers of cyathia which were in each of the categories: tight green bud (stage 1); showing colour (stage 2); with pollen (stage 3); open stigma (stage 4), or with both pollen showing and open stigma (stage 5). In practise, it was rare that stages 3 and 4 occurred independently. Increasing temperature affected the interaction between bract size, bract colour and stage of cyathia development at marketing. The rate of cyathia development, changes in bract size, and loss of bract colour are all greater with increasing temperature.

- ***Overall***, quality at marketing was judged to be best in Sonora and Lilo. Quality was reduced in plants finished at higher temperatures due to larger, more faded, and advanced cyathia development (resulting in cyathia with reduced shelf-life potential).

  Any differences in growth or quality due to temperature treatment were due to the temperature applied in the first part of the trial, with transfer treatments having little or no effect compared to the treatments maintained at the lower or higher temperatures.

- Reduced production delays, combined with enhanced quality of bract and foliage, and cyathia longevity may make late-season cool-growing a more attractive approach for maintaining quality at this time of year than extended season cool-growing techniques.

▫ Light

The plants were grown (throughout production) under a range of simulated light environments (shaded, ambient or lit using 3 klx provided by SON-T 400). This investigated the interactions between light and temperature that could occur in different seasons (e.g. cool and dull or warm and sunny), and their effects on plant quality and shelf-life performance.

- Plant quality at marketing was markedly affected by light level, with production in low light further accentuating any negative effects of temperature.

- Poor light enhanced crop delays associated with cool-finishing whilst high-light offset these delays.

- At any given temperature, plants grown in high- or ambient light produced larger, more highly coloured bracts than plants grown in low-light.

- Cyathia production and development was greatly reduced in low-light conditions, and there was a high incidence of premature cyathia abortion / loss in all varieties.

❑ Shelf-life at the standard marketing stage (effects of Light * Temperature)

- The shelf-life data (observational trial) indicate that although cool-finished plants kept their colour best throughout shelf-life, the bracts tended to be more susceptible to *Botrytis* and the rate of bract loss was slightly increased when compared to plants finished under warmer conditions.

- If plants were transferred from 15 to 21°C for the final 3 – 4 weeks of production, as might occur when attempting to speed up a crop for a specific market date, there were noticeable increases in the leaf drop rate later on in shelf-life compared to the other treatments.

- There was no consistent effect of light level on the rate of leaf or bract loss during shelf-life, but because plants grown in low-light had paler leaves and bracts when going into shelf-life, their score was consistently lower throughout shelf-life than in plants grown under higher light.

- Of the varieties tested, Lilo was consistently good in shelf-life, followed by Freedom and Sonora, with Spotlight performing worst, largely due to increased occurrence of *Botrytis* in this variety.

❑ Effect of stage of plant development at marketing on shelf-life performance

In addition to the effects of light and temperature on plant quality and shelf-life, the stage of development at marketing was another factor that had not previously been addressed. Currently, there are no defined criteria, beyond degree of bract colouration, on which to base the optimal stage at which to market Poinsettia in order to ensure the best post-harvest performance of the product. The current work has identified how cyathia development can be used as a key indicator for marketing in varieties with varying response times, and demonstrates how temperature affects cyathia development in relation to bract colour.

For the trial, plants from each temperature were removed to shelf-life at 3 marketing stages: 1 = Early (one bract yet to colour up); 2 = Stage 1 + 10 days, and 3 = Stage 1 + 20 days. At each stage, plant maturity was assessed in terms of cyathia development as described earlier.

The optimal market stage should reflect the point where bract size and colour are well balanced, with cyathia at a developmental stage which will provide the consumer with the longest appreciation of an 'intact' plant (i.e. with cyathia present rather than absent).

Delayed marketing and temperature both affected bract size, colour and cyathia development (and loss). At lower temperatures, bract size and colour changed very little with delayed marketing, and because cyathia developed more slowly, there was scope for delaying marketing without losing cyathia or plant impact at the point of sale. When finished at higher temperatures, the balance between bract size and colour is more difficult to achieve since colour rapidly fades as bracts expand. By delaying marketing, the grower risks producing a plant with large, faded bracts with the added disadvantage that cyathia will be so far developed that they will drop easily and provide poor retail and home-life satisfaction.

When marketed early, cool-finished plants showed less leaf or red bract drop compared to plants finished at 18 or 21°C. However, when marketing was delayed, the benefits of cool-finishing were diminished, and warmer-finished plants retained more leaves and bract leaves. Cool-finished plants had better foliage and bract colour at each marketing stage, and this persisted throughout shelf-life.

In cool-finished plants (15°C on graphs), the cyathia developed slower than at 18 or 21°C and were also dropped later. This resulted in many more cyathia remaining on the cool-finished plants during shelf- / home-life when marketed later, providing a more 'complete plant' for longer than if finished at warmer temperatures.

- ***Overall***, the earlier the plants were marketed, the better they performed during shelf-life. The danger with holding plants at lower temperatures to delay marketing for long periods was that there may be an increased chance of poor leaf and bract keeping qualities post-harvest.

New Varieties

With the number of new Poinsettia varieties spiralling, it is increasingly important for growers to test and preview their performance alongside some more established varieties as a benchmark. This year, 12 varieties (including 4 numbered varieties) were grown at 4 commercial grower holdings to test them in a wide range of environments and cultural practices, before being transferred to HRI Efford for shelf-life assessments.

The varieties tested were: Christmas Carol, Sonora (2 selections), Santa Claus & White Christmas, Lilo, Coco Red, Malibu, Tabaluga, Xenia, 457 & 2969.

Of the above varieties, Xenia, Coco Red, and Lilo were all judged, on average, as being of better quality at marketing than the rest, with Christmas Carol, Sonora and Santa Claus judged as being poorer-than-average under the conditions in the current trial.

At de-sleeving, the Sonora was prone to high incidence of *Botrytis* in the canopy. This was associated with the proliferation of small shoots produced at the base of the canopy.

During shelf-life green leaf and bract losses were recorded together with colour scores and cyathia development. One month after de-sleeving, data from each variety were compared.

- Leaf and bract losses were low in Malibu, Lilo, Christmas Carol and 2969, and higher-than-average in Sonora, Tabaluga and White Christmas. The impact of leaf and bract losses were less noticeable in Sonora in which smaller- (secondary) rather than the larger (main) leaves and bracts were shed.

- 457, Malibu, Xenia and Lilo all retained good quality foliage and high bract colour scores during shelf-life, with paler foliage and bract fading predominating in Coco Red, Tabaluga Red, Santa Claus, 2969 and Christmas Carol.

- Santa Claus, White Christmas and Sonora all retained significant numbers of cyathia during shelf-life, whereas Coco Red, 457, Malibu and 2969 tended to lose cyathia early on.

- ***Overall*** shelf-life performance was better-than-average in Xenia, Malibu, Lilo and 2969, with poorer-than-average performance from Tabaluga, Coco Red, and Santa Claus. Performance of Sonora was variable between the two selections tested and factors that led to these differences cannot be determined from the available current data.

❑ Propoxur smoke

Late infestations of whitefly are a problem to Poinsettia growers, especially if in an area where protected tomatoes and cucumbers are being produced. Currently, Propoxur smoke (Fumite Propoxur Smoke; Hortichem Ltd) has approval for use as a general insecticide in glasshouses with protected chrysanthemums and carnations on the label. Poinsettia are not a named approved crop and so growers who use this product do so at their own risk. The current work aimed to identify whether or not the potential risk to growers (in terms of reduction of crop quality due to phytotoxic effects) is high when using Propoxur in the recommended way against late-season whitefly infestations. This sub-trial evaluated the potential for using Propoxur smoke (applied at the recommended rate) for the control the adult fly followed 10 days later by Applaud (at a rate of 3 ml /10 l) to control the larval stages. 14 Varieties (reds, pinks and whites) were tested in a fully randomised block design. Care was taken to ensure that all precautions were taken to avoid crop damage due to inappropriate application of propoxur i.e. (i) plants were in good condition; (ii) they were fully irrigated several hours prior to fumigation; (iii) all leaf surfaces were dry at the time of fumigation; (iv) humidity in the compartment was high; (v) paths were damped down; (vi) fumigation was done late-evening and through the night to avoid the risk of sun-scorch.

From the available data, the combination of Propoxur smoke and Applaud applied at the recommended rates had no obvious deleterious effects on the plants when applied to crops in full colour. The only instances where slight bract edge damage was noticed were in the Highlight White

during the trial appeared to be no more than would be expected from naturally ageing plants over the same period.

- ***Overall***, there were no consistent trends in the data that suggest the treated plants deteriorated any quicker following Propoxur / Applaud treatment than the untreated controls.

Action points

Effects of cool-growing at the end of production on plant quality at marketing:

- Reduced production delays, combined with enhanced quality of bract and foliage, and cyathia longevity may make late-season cool-growing (15% post initiation) a more attractive approach for maintaining quality at this time of year than extended season cool-growing techniques.

- Finishing pots at 15°C from week 43 delayed the crop by an average of 7– 10 days (and longer in low light). Although this delay was far less severe than in crops produced with whole-season cool-growing (see 1995-96 trials), cool-finished crops should be potted at least a week earlier.

- Cool growing post initiation can reduce excessive bract size and colour fading problems associated with some varieties grown under conventional temperature regimes (e.g. Freedom).

  With Spotlight, which produces small bracts, reduced bract size as a result of cool growing, can be offset by increasing temperatures again from Week 46.

  Sonora and Lilo produce consistantly high quality plants over a range of temperature regimes.

- Cool finished plants retain better bract colour during shelf life.

- Cool growing post initiation delays cyathia development with the advantage of potential for continued development during shelf-life.

- Cyathia number and stage of development were strongly affected both by temperature and light, with cool growing delaying cyathia development at the standard marketing stage (relative to bract colouration). This resulted in cool grown plants having more intact cyathia at harvest than in comparable plants finished at 21°C with the potential benefits of continued cyathia development during shelf life. Low light levels during production restrict the numbers of cyathia reaching maturity, with many immature buds being aborted and dropped before marketing.

- In varieties with rapid cyathia development e.g. Lilo, market early and use cool finishing to check cyathia development for a more 'complete' plant at marketing.

- In varieties where cyathia development is very slow e.g. Spotlight, you can afford to manipulate temperature both up and down later in the season with relatively little impact on cyathia development.

- Cool finished plants retained better bract colour during shelf-life when marketed later than plants finished at 21°C.

- Optimal marketing stage will depend on temperature under which the crop is grown. Each variety will respond differently to any given temperature regime depending on relative rates of bract colouration : cyanthia development.

- Early marketing improves shelf-life potential, especially in cool finished plants. Here a delay of more than 7-10 days in marketing may result in increased bract and leaf loss during shelf-life compared to 'warmer' finished crops.

- New varieties from commercial production which exhibited good shelf-life properties included Xenia, Malibu, Lilo and 2969.

- A late season application of propoxur smoke followed by Applaud for control of white fly was safely used over a range of Poinsettia varieties at advanced bract colour. However, application of these pesticides must be carried out according to the specific recommendations of the chemical manufacturer. The plants must be well-watered and not under stress at the time of treatment to reduce risk of damage. This application does not have label approval for Poinsettias and must therefore be used at 'Growers Risk'.

- High quality, good colour and "completeness" of cool-finished plants at marketing offer both the grower and retailers significant benefits in the market place over products which have been finished warmer. These benefits need to be offset against any increase in duration due to cool-growing for a period of production.

- Early marketing can benefit the grower in two ways: (i) offset the delay in a cool-finished crop (marketing a week earlier will reduce / cancel the net crop delay due to cool-finishing); (ii) early marketing also gives added benefits in terms of quality and increased post-harvest longevity for the consumer from plants grown in any temperature regime.

Small savings in the number of plant growth regulator applications may be beneficial not only in terms of reduced cost, but will also have value to the grower in producing a more "environmentally-friendly" pot plant.

2. EXPERIMENTAL SECTION

2.1 Introduction

Temperature regimes for the production of Poinsettias for the UK market has formed the subject of investigation for the last two years at HRI Efford (reported in final report for HDC PC 71c). Valuable results have emerged from this work in terms of influence on speed of production and final plant quality as well as potential savings in energy costs and growth regulator inputs. Treatments on Poinsettias to date have studied the whole production period from potting to marketing during which different phases of growth take place. Initially plants will be forming roots and growing vegetatively (forming leaves in the meristematic tissues). As day-length shortens however, flowers become initiated, and the final growth comprises of flower development and expansion and coloration of leaves and bracts. Temperature may therefore impact on these different developmental processes in different ways. The period during which improvements in production may be most readily achieved is the final phase when the initiated plant is maturing. This phase of development coincides with the period during which solar radiation levels begin to decline, which inevitably restricts the final quality produced.

Results from the 1995 and 1996 trials showed that a number of varieties could be produced at lower temperatures, and that linked to this, significant economic benefits could be made, both in terms of energy for heating the glasshouse and in the number of growth regulator applications.

In 1996, the trial included a shade treatment to provide different light environments in which to test the effectiveness of cool-growing techniques, combined with increased pot density, to look at the potential increased return / unit area without compromising quality.

During these trials it was demonstrated that cool-grown plants needed to be potted 2 - 3 weeks earlier than warm-grown controls to produce plants of marketable quality, and that shading reduced plant quality overall. The effect of whole-season cool-growing on shelf-life was variable between years. Although significant savings were seen in the energy cost for cool-grown crops, this had to be offset against the longer crop duration under these conditions.

Savings in growth regulator application to cool-grown crops were most marked in 1995 when plants were growing vigorously, but because plants had to be grown longer at low temperatures, the savings in plant growth regulation over the growing season were much less than expected.

Following on from the 1995-1996 work, this 1997 trial examines how temperature influences the final phase of plant development of Poinsettia production by combining a standard initial temperature regime until initiation with a lower temperature regime for the final stages of production. The aim was to achieve the quality benefits of cooler growing with a reduction in the

delay which would normally be expected from full season cool growing as imposed in the previous trials. The trial also incorporates a range of light levels to investigate the effect of the interactions between light and temperature on plant development and quality.

Previous HDC funded work with pot chrysanthemums has clearly demonstrated the significant impact that stage of plant development may have on final keeping quality of the product. Currently, there are no clearly defined marketing stages for Poinsettia varieties, or how the developmental stage at marketing may impact on shelf-life. The current trial has studied the impact of marketing stage on post-harvest performance in four Poinsettia varieties.

One problem that Poinsettia growers face is the threat of late-season white-fly infestations at the time when tomato and cucumber production stops and the white-fly populations resident on these crops look for 'new homes'. In warm autumn and winter periods such as those experienced in 1997, this can add significantly to the white-fly problems in the Poinsettia crop at a time when many growers may have stopped their weekly introductions of *Encarsia formosa*. Although propoxur smokes have previoulsly caused some phytotoxicity symptoms have been used in the past for control of white-fly on Poinsettia, the programme of repeated smokes though when applied early in the crop, the plants could outgrow these effects without any detrimental impact on the final product. In recent years, new products have emerged that can be used effectively against white-fly larvae. It is possible that when used in a combined programme, propoxur need only be applied once and this may reduce or eliminate any signs of phytotoxicity. If this is the case, then late-season infestations of white-fly (as seen in 1997) could be effectively controlled without harming the crop.

Therefore, as an additional part of the current trial, it was decided to incorporate a separate trial (in liaison with Fargro Ltd), to test the viability of late-season applications of propoxur smoke with Applaud (buprofezin) as an effective control of white-fly during this period of production (when bracts were coloured).

Finally, new varieties remain high on the agenda of both the grower and the retailer. Shelf life work in previous years at Efford has included an investigation of the keeping quality of plants grown on different commercial nurseries. This work has identified the great impact that cultural factors can have on shelf life. Since new varieties must have good shelf life to succeed in the current market, an extension of this approach was proposed, with a range of new varieties grown at different nurseries will be examined under the shelf life testing facilities at Efford. It was possible using this approach to identify which of the new varieties, when produced in a range of different environments, performed best during shelf-life.

2.2 Objectives

- To investigate the impact of different temperature regimes under simulated high, average and low light conditions during the final phase of plant development in Poinsettia production, and to develop methods for manipulating temperature to maximise quality and scheduling of flower / bract development.

- Identify how manipulation of temperature in similated high, medium and low light years during the final phase of growth may improve performance in shelf-life.

- To objectively define optimal marketing stage that enhances shelf life properties of key commercial cultivars.

- Provide the grower with valuable information about new varieties to assist in making selections for the next season.

- To study whether or not a late-season application of a propoxur smoke followed by Applaud to combat white-fly infestations at or close to the marketing period, produced any phytotoxic symptoms in a range of varieties.

2.3 Material and Methods

2.3.1 Glasshouse site

The trial was run in three compartments of Q Block (Q 1 – 3). Compartments run north – south with corridors running along the northern side. Benching within each compartment is aligned north – south. Each compartment contains twelve 6.8 * 1.8 m benches, four across the width and three along the length.

2.3.2 Poinsettia cultivars for main trial

Variety	Source of young plants
Freedom	W.J. Findons
Sonora	W.J. Findons
Lilo	W.J. Findons
Spotlight	Hollyacre Plants

2.3.3 Treatments

2.3.3.1 ***To investigate the effect of interactions between light and temperature on plant quality:***

a) Three light level treatments:

- Ambient light
- Low light (provided by shading) to represent a year with below-average light levels (central area in each compartment).
- High light to represent a year with above-average light levels. SON-T lamps set to provide a uniform 3K lux at canopy height from 30 min post-dawn to 30 min pre-dusk: northern end of each compartment (see Appendix 1).

b) Three temperature treatments applied from week 43 to market:

- 15°C (vents set to open at 16°C)
- 18°C (vents set to open at 19°C)
- 21°C (vents set to open at 22°C)

Two additional treatments investigated potential benefits of further splitting the final phase of growth into two equal parts (weeks 43- 46 & 47 - 51) and transferring plants between common lighting treatments the two extreme temperature treatments only (15 & 21°C) to give two further treatments:

- 15°C from week 43 to week 46 and 21°C from week 47 onwards.
- 21°C from week 43 to week 46 and 15°C from week 47 onwards.

2.3.3.2 ***Impact of physiological development at marketing on post-harvest performance:***

Plants from the ambient light treatment within each temperature treatment were selected at each of 3 developmental stages for shelf-life assessment:

- **Stage 1** Earliest marketing stage (defined as the point at which one bract in the top star was still developing colour, but all other bract leaves were fully coloured)

- **Stage 2** 10 days after stage 1
- **Stage 3** 10 days after stage 2

Compartment layouts are presented in Appendix 1a – c, with plot layout in Appendix 1d

2.3.4 Experimental Design

Four cultivars by 3 light levels by 5 temperature treatments. The trial was then analysed as a split-plot design with two replicate blocks each containing 3 sub-blocks for the light levels, and with cultivar by temperature combinations effectively being randomly allocated within these sub-blocks. The nature of the temperature treatments meant that each temperature was applied to a separate compartment, but as the replicate by lighting block combinations occupied the same relative positions within each compartment, for analysis it was possible to treat these as complete blocks across the compartments.

The marketing stage treatments were effectively applied as sub-plot treatments within each of the plots as described above, with plants randomly allocated to each of the 3 stages prior to reaching this stage.

4	cultivars
x	
3	light levels
x	
3	temperatures
x	
2	replicates
--	
72 Plots	

Plus transfers between common light environments in 15°C and 21°C:

4	cultivars
x	
3	light levels
x	
2	transfers / light level
x	
2	replicates
--	
48 Plots	

The 15 and 21°C compartments each contained 48 plots (24 main trial plus 24 transfer plots), with the 18°C compartment containing 24 plots (no transfers).

Based on plant density at final spacing of 10/m^2:

5 pots per row with pot centre - pot centre spacing = 31.6 cm within rows and row-row spacing = 27.4 cm (staggered spacing)

Plotsize = 25, with 9 recorded plants / plot (additional plants in the plot will provide those for early removal to shelf-life).

2.3.5 Cultural Techniques

i) Propagation: Plants potted in 13C pots using SHL Poinsettia compost. Plants were pinched approximately 7 - 10 days after potting (when roots had begun to explore the media and reach the pot sides). Pinching was applied by cultivar with 'Freedom', 'Sonora' and 'Spotlight' pinched to 6 leaves, and 'Lilo' to 8 leaves to achieve 5-6 heads at marketing.

ii) Schedule: From potting in week 31, until week 43, plants were grown in a common environment according to standard commercial practice. Plants were grown pot thick from week 31 until good breaks were produced, and then moved to half spacing (20/m^2: 22.3 cm pot-pot & 19.4 cm row-row) and to a final spacing (10/m^2: 31.6 cm pot-pot & 27.4 cm row-row) as required before treatments were imposed. Natural day-length was maintained across all treatments throughout the experimental period. Where supplementary lighting was used, it was controlled to switch on 30 minutes after dawn, and off 30 minutes before dusk to avoid any photo-periodic effects). After the Autumn equinox (week 39) all measures were taken to ensure that plants were not exposed to extraneous light during the night (to avoid delayed flowering / revertion to vegetative growth). After

the initial establishment and initiation stage (weeks 31 - 43), plants were transferred into the appropriate treatments.

iii) Environment / Nutrition:

Temperature & light: During the initial phase of the trial, temperature regime was run according to standard commercial practice using the recommendations of the crop consultant as follows:

Week number	*Day Temperature (°C)*	*Night temperature (°C)*	*Vent temperature (°C)*	*Light threshold (W/m^2)*
31	20	20	22	300 (+ fleece)
32	20	20	22	400 (- fleece)
33	20	20	22	550
36	18	20	19/20 (D/N)	
42	16	16	17	
43	Start of treatments 15/18/21	Start of treatments 15/18/21	Start of treatments 16/19/22	
46	Transfers			

CO_2: From fleece-removal until marketing CO_2 was enriched to 500 ppm with vent settings up to 3%.

Nutrition: Was applied according to the recommendations of the crop consultant as follows:

Weeks 32 - 34: Calcium nitrate: 125 ppm N, pH 6.0 (EC 0.7 plus background)

Weeks 34 – 40: Early season feed: 225 ppm N, 40ppm P,175ppm K, 40ppm, Mg+Librel BMX 10gl^{-1} @ 1:100; Ca-EDTA 10gl^{-1} @ 1:100

Weeks 41 – 44: Main season feed: 175 ppm N, 40 ppm P, 175 ppm K, 40 ppm, Mg+Librel BMX 10 g l^{-1} @ 1:100; Ca-EDTA 10 g l^{-1} @ 1:100

Weeks 44 – market: Late season feed: 150 ppm N, 40 ppm P, 175 ppm K, 40 ppm, Mg+Librel BMX 10 g l^{-1} @ 1:100; Ca-EDTA 10 g l^{-1} @ 1:100

iv) Pest and Disease Control: Integrated pest management control measures were used concentrating on biological control programmes (where possible). To control Sciarid larvae, Nemolt was applied as a drench (0.7 ml l^{-1}) in weeks 32 and 37, with *Hypoaspis miles* introduced from week 41 (300 /m^2). To control white-fly, *Encarsia formosa* were introduced, with a single Applaud application (0.3 ml l^{-1}) in week 45.

v) Plant Growth Regulation: Plant height was monitored using the Pointer graphical tracking system and height was controlled using Cycocel® throughout production (for application number and rates, see results section). First application was when breaks were between 1-2 cm long.

2.3.6 Shelf-Life

At marketing, plants were sleeved, boxed and held at ambient packing shed temperatures for 2 days before being put into shelf-life. The shelf life rooms were maintained under average supermarket retail conditions (based on the response of supermarkets to a questionnaire conducted by HRI Efford) with temperature set-point = 18°C (day & night; see Appendix 2), RH at 60 - 70% and 1000 lux lighting provided by white fluorescent tubes (14 h day). Plants were de-sleeved after 10 days in shelf-life, and records were taken at the point of de-sleeving, 3 and 7 days later and at weekly intervals thereafter for 6 weeks.

All treatments were put through shelf-life. The shelf-life objective of the project was to determine the effect of marketing stage on post-harvest performance (ambient light treatment for 15, 18 and 21C treatments only (not transfers)). For this reason, statistical analyses were carried out for this part of the shelf-life trial. The data for the other observational treatments are presented graphically and although useful trends can be observed, any inferences re- treatment effects drawn from these data have no statistical significance attached to them.

For the study of the effect of marketing stage on post-harvest performance, all pots were put through one shelf-life room (new room 3). The room was split into 2 blocks (half room / block), with one replicate plot for each marketing stage in each half of the room (to take account of within room variability). Within blocks, replicates were fully randomised.

2.3.7 Experimental Records

2.3.7.1 Growing phase

Efford trial: Effect of light and temperature on final growth stages.

1 Routine assessment of the quality of cutting

2 At weekly intervals: Plant height from pot rim to tallest growing point for graphical tracking

3 Four weeks after potting:
- a - Plant height - cm (from pot rim to top of foliage)
- b - Number of breaks
- c - Quality / uniformity

4 At the start of treatments (week 43) apical dissection of each to assess floral initiation.

5 Date of first colour per plant.

6 Date of first visible cyathia per pot.

7 Date of first pollen showing per pot.

At marketing:

a - Date of marketing.

b - Plant height - cm (from pot rim to top of foliage)

c - Plant diameter - cm (across widest point and at 90 degrees)

d - Number of breaks on each plant

e - Number of heads on each plant within each of four size grades:

Size grade (i) < 150 mm
Size grade(ii) 150 - 200 mm
Size grade(iii) 200 - 225 mm
Size grade(iv) > 225 mm

f - Size (length & max. width) of largest red leaf or bract per plant - cm.

g - Note of foliage and bract colour plus any disorders.

h - Cyathia number and developmental stage (on tagged dominant break; see photos in Plate 1):

Stage 1 = green
Stage 2 = showing colour at the tip
Stage 3 = pollen showing (without stigma opening)
Stage 4 = stigma open (without pollen showing)
Stage 5 = pollen and stigma together

i - Score of overall quality

(i) Score 0 = Unmarketable
(ii) Score 1 = Second Grade
(iii) Score 2 = First Grade

Plant growth regulation:

- Total number of applications / plot / variety
- Timing and rate of each application

Media analysis: Taken at potting and at 2 week intervals thereafter (samples bulked across variety and light treatment within each temperature compartment).

Liquid feed analysis: Every two weeks

2.3.7.2 ***Shelf-life phase (2 plants per plot (= 4 per treatment))***

a - Number of leaves dropped

b - Number of red bracts dropped

c - Cyathia development / loss (scored as described above for the marketing records)

d - Mechanical damage score:

Score 0 = none
Score 1 = slight
Score 3 = moderate
Score 5 = severe.

e - Leaf colour score:

Score 0 = dark green
Score 1 = slight paling
Score 3 = moderate paling
Score 5 = severe yellowing.

f - Bract colour score:

Score 0 = no damage / colour loss
Score 1 = slight loss of colour
Score 3 = bracts paling and marked
Score 5 = severe bract fading and damage.

2.3.8 **Environmental Records**

- External day, night and 24 hourly average temperature
- External day, night and 24 hourly average relative humidity
- External irradiance (daily light sum)
- Compartment day, night and 24 hourly average temperature
- Compartment day, night and 24 hourly average relative humidity

2.4 New Variety Trials

Grower holdings:

These were selected to cover a significant range of UK Poinsettia production with very different ambient light and temperature environments. 12 new varieties (with some more established varieties to act as bench-marks) were tested under the range of conditions of production across these holdings.

1	Evans and Sons (Hadlow, Kent)
2	Double-H Houseplants Ltd (New Milton, Hampshire)
3	Oakheart Ltd (Stapleton, Leicestershire)
3	Tyson and Coletta (Hull, East Yorkshire)

Varieties

1	Lilo	7	Santa Claus
2	Sonora (selection a)	8	Tabaluga Red
3	Sonora (selection b)	9	White Christmas
4	Christmas Carol	10	Xenia
5	Coco Red,	11	457
6	Malibu	12	2969

25 plants of each of the 12 varieties named above were sent to each of the four grower holdings. The plants were grown according to the commercial practices on each holding and records were collected by an independent recorder after pinching (plant height and number of breaks) and at marketing (plant height & spread, number of bracts & shoots, star diameter, quality score & marketability score). At marketing, plants were sleeved, boxed and sent to HRI Efford for shelf-life evaluation. Full records of cultural conditions for each holding were also made available at marketing.

2.5 Propoxur smoke Trial

Plants in the final phase of production were sourced from the trial and a local nursery*

1	Lilo	10	Santa Claus
2	Spotlight	11	Tabaluga Red
3	Sonora	12	White Christmas
4	Freedom	13	Xenia
5	Christmas Carol	14	457
6	Coco Red	15	2969
7	Malibu	16	Marble Star
8	Maren	17	Monet
9	Highlight White		

* Plants of varieties assigned "" were kindly provided by Double-H Houseplants Ltd

Six plants of each of the varieties listed above were treated as follows: 4 designated as 'treatment' plants, with the remaining 2 as 'control' (untreated) plants.

Plants were arranged in two fully randomised blocks in a single compartment of K Block, with half of the plants from each variety assigned to a block (one block in each half of the compartment to take account of any possible variation within the compartment). The compartment was held at 18°C. On the 3/12/97 a series of non-destructive records of cyathia development and of bract and foliage colour and quality were made. On the evening of 3/12/97, the compartment was treated with propoxur smoke at 1.2 times the recommended rate (propoxur 6000 bomb treats 168 m^3, volume of compartment was 283 m^3 requiring 2 bombs sufficient for 336m^3 = 1.2 x recommended rate), taking all appropriate precautions in line with the manufacturer's recommendations as follows:

(i) Plants were in good condition. (ii) Plants were fully irrigated several hours prior to fumigation. (iii) All leaf surfaces were dry at the time of fumigation. (iv) Humidity in the compartment was high. (v) Paths were damped down. (vi) Fumigation was done late-evening and through the night to avoid the risk of sun-scorch.

The following morning, the compartment was vented, and the plants were moved into Q block where they were held at 18°C, along with the control (untreated) plants, under ambient light conditions (pot density 10 / m^2). After 9 days (12/12/97), a second set of records were taken to see whether the smoke treated plants showed any signs of phytotoxicity. Following the second assessment, the plants were sprayed with Applaud (3 ml / 10 l).

A final assessment was made on 22/12/97 (19 days after the initial treatment).

3. RESULTS AND DISCUSSION

3.1 Efford trial

3.1.1 Effect of late-season cool-growing on plant quality at marketing

- **External conditions (Appendix 2):** Weeks 35 – 40 were warm in line with the higher than average radiation figures for the time of year (Fig 2). Overall, the total light received during the 1997 trial was 0.08% lower than 1996 and 2.4% higher than 1995. There was a sharp drop in average external temperature to 5°C between weeks 42 and 44 followed by a rapid recovery to 10°C by week 45. Mean external temperature remained in the region of 7.5 – 12.5°C from the remainder of the trial.

- **Production environment (graphs in Appendix 2):** All trial plants were held in Q2 until week 34, when they were moved out into the other treatments. Between weeks 34 and 41 (pre-treatment) night temperature was elevated slightly in Q3 compared to the other compartments, potentially applying a small DIF in this compartment (Appendix 2, Fig. 4). From graphical tracking data, there is no evidence for height reduction in Q3 compared to the other compartments, so this period of elevated night temperature had no observable effect on the crop. From week 42 onwards, compartment temperatures were controlled in-line with treatment requirements (see Appendix 2, Fig. 3).

  Relative humidity (RH) varied between 60 - 80% before treatments. After the start of treatments RH was higher in the cool compartment as may be expected (Appendix 2, Figs. 6 – 8). By maintaining an active growing environment at dawn (positive heat and venting), leaf and bract spotting due to cell bust was minimised.

- **Plant growth regulator (PGR) use:** Data in Table 1 show the breakdown of PGR applications before and after the start of treatments, and how growing temperature (after the start of treatments) affected the number of applications required to meet the market height specification. Lilo and Spotlight both required heavy regulation throughout production, with up to 31 applications required in Lilo. In order to keep within height specification, it was necessary to use an Alar/Cycocel mix on the warmer-grown Lilo and Spotlight (but not in the 15°C treatment). Sonora and Freedom needed far lower PGR inputs, only one third of the requirement for Lilo/Spotlight, and there were no applications on either Sonora or Freedom after the start of treatments. There was little to be saved in terms of PGR inputs through the use of cool-growing when imposed from week 43, with 1 – 2 fewer applications in the 15°C Lilo and Spotlight, compared to the warmer regimes.

Table 1: PGR applications; effect of late-season cool-growing on number of applications

		Pre-treatment											
		Lilo			**Spotlight**			**Freedom**			**Sonora**		
CCC (46% a.i.)	0.5 ml/l	-			-			3			3		
	1.0 ml/l	7			10			7			7		
	1.5 ml/l	5			5			-			-		
	2.0 ml/l	12			7			-			-		
Alar/CCC (1.0 g/l:1.0 ml/l)		3			-			-			-		
Total number of applications pre-start of treatments		**27**			**22**			**10**			**10**		
		Post start of treatments											
Treatment		15°C	18°C	21°C	15°C	18°C	21°C	15°C	18°C	21°C	15°C	18°C	21°C
CCC (46% a.i.)	1.5 ml/l	-	2	1	-	1	1	-	-	-	-	-	-
	2.0 ml/l	2	2	2	2	2	2	-	-	-	-	-	-
Number of applications post- start of treatments		**2**	**4**	**3**	**2**	**3**	**3**	**0**	**0**	**0**	**0**	**0**	**0**
TOTAL		**29**	**31**	**30**	**24**	**25**	**25**	**10**	**10**	**10**	**10**	**10**	**10**

Marketing records

The photographs in Plates 2 – 5 show the effects of imposed temperature and light treatments on plant appearance at marketing in Sonora (Plate 2), Spotlight (Plate 3), Freedom (Plate 4) and Lilo (Plate 5).

- **Production time (Appendix 3, Fig 1):** Average production time was significantly different between each variety (P = 0.05; LSD = 2.71 56 d.f.), with the shortest duration in Freedom (125.1 d), then Lilo (130.8 d), followed by Spotlight (137.9 d) and Sonora (142.47 d). Across varieties, there was a significant effect of temperature (P=0.5.; Table 3), with cool-growing post initiation delaying crops by an average of 10 days compared to the 18 or 21°C treatments (no significant differences between 18 and 21°C).

  The temperature transfer treatments (15 - 21°C and 21 - 15°C) had little or no effect compared to the treatments maintained at the lower or higher temperatures.

  Shading also significantly extended the average delay by 7 days compared to the ambient and lit treatments (P = 0.05; Table 4). Again, there was no significant reduction in duration in lit compared to ambient light levels. Lilo appeared to be less sensitive to light level than the other varieties tested.

- **Plant height (Appendix 3, Fig 2):** All treatment effects were confounded to some extent with the use of growth regulators. Overall, cool-grown plants were significantly shorter (P = 0.05) than plants grown at 21°C, with no significant difference between the 18 and 21°C treatments (Table 3). Again, the temperature transfer treatments (15 - 21°C and 21 - 15°C) had little or no effect compared to the treatments maintained at the lower or higher temperatures.

  Lilo and Spotlight were taller than Sonora and Freedom (P = 0.05). Only 15°C Sonora failed to reach the required specification for height (by 1.8 cm), with plants in the 21°C treatment too tall in Spotlight and Lilo (by 2.8 and 2.4 cm respectively).

  The data suggest that Sonora is generally too short for it to be possible to be grown in the lower temperature regime. Both shading and supplementary lighting tended to suppress plant height slightly in Lilo and Spotlight, the more vigorous varieties but was not statistically significant. There were no signs of shade-induced stretch.

- **Plant diameter (Appendix 3, Fig 3):** Of the 4 varieties, Spotlight was consistently more bulky than the other varieties in terms of plant spread, in line with its vigour and number of breaks. Lilo (the other vigorous variety) showed a much more upright and compact habit consistent with fewer breaks / plant. Freedom appeared most temperature sensitive, with cool-grown plants consistently more compact than those grown during the initial phase of treatment at 18 or 21°C. Plant diameter was significantly reduced in the cooler temperatures (P=0.05; Table 3), but a samll reduction in diameter as a result of low light did not prove significant.

- **Breaks:** The number of breaks was determined for each variety before the imposition of treatments. On average, Spotlight, Freedom and Sonora all produced > 6 breaks / plant, with Lilo producing on average only 5 breaks / plant. There was no consistent effect of temperature or light treatment on the number of breaks reaching maturity in any of the varieties tested.

- **Time to bract colour (Appendix 3, Fig 4):** For any given variety, there was little effect of temperature on the time to first bract colour. Bracts showed colour in Freedom by days 75-78, followed by Spotlight, Sonora and Lilo (83 – 86 d). Within each variety, there was little interaction between temperature and light on time to first bract colour, but the data indicate that bract colouration may be delayed by up to 2 days under shade. Green shade, as used for this trial, may have a small impact on the rate of anthocyanin production, accounting for the delay in bract colouring.

- **Bract leaf size (Appendix 3, Fig 5):** For analysis, bract leaf size was determined as the product of length x maximum breadth. Freedom and Sonora had significantly larger bract leaves ($P = 0.05$) than Lilo or Spotlight. Bract size was affected by temperature, with cool grown plants having significantly smaller bract leaves (up to 30% smaller) than the average for the 18°C treatment, and with plants grown at 21°C producing significantly larger bract leaves (Table 3). Bract size could be manipulated by late-season transfer, with increases in bract size stimulated by transfer from 15 – 21°C (compared to 15°C throughout), and reductions with transfers from 21 – 15°C (compared to 21°C throughout). If a particular bract size is preferable, different temperature regimes might be appropriate for different varieties.

  Lilo was the only variety in which bract splitting was commonly seen across ALL treatments.

- **Bract size distribution (Appendix 3, Fig 6a-d):** Cool-growing led to a significantly higher proportion of bract stars in the smaller size classes (< 150 and 150 – 200 mm), and significantly ($P = 0.05$) fewer bract stars of > 225 mm when compared to plants grown at either 18 or 21°C (Table 2). In plants grown at 21°C, there were significantly more bracts in the > 225 mm class than at either 18 or 15°C. Both cool-growing, and transfer from high to cool temperatures produced higher numbers of smaller bracts in Spotlight than in the other varieties, but average bract star size was reduced with lower temperatures in all varieties.

Table 2: Effects of temperature at the end of production on % bracts in each size class at marketing.

Temp. (°C)	Bract star size class (mm)							
	< 150		150 - 200		200 - 225		> 225	
	ATP	%	ATP	%	ATP	%	ATP	%
15	26.97	20.57	39.48	40.43	25.25	18.20	19.26	10.88
18	16.08	7.67	27.04	20.67	25.49	18.52	41.94	44.68
21	12.36	4.59	20.31	12.05	20.74	12.54	52.68	63.26
15 – 21	12.96	5.03	24.90	17.73	27.23	20.94	44.71	49.50
21 – 15	12.45	4.65	22.83	15.06	24.59	17.32	48.08	55.37
LSD 5% (56 d.f.)	4.00		4.73		4.60		5.71	

ATP = Angle transformed percentage (for statistical analysis)

- **Bract colour score (score 0 [worst] - 5 [best]; Appendix 3, Fig 7):** Bract colour was inversely related to bract leaf size: i.e. smaller bract leaves scored higher for colour intensity and uniformity than larger bract leaves. In all varieties, warm-growing significantly reduced bract colour when compared to plants grown at 15 or 18°C (P = 0.05; Table 2). However, if using cool temperatures to maintain bract colour, the potential detrimental effects of cool-growing in reducing bract leaf size in some varieties must be borne in mind. In Spotlight and Lilo, late transfer from 21 - 15°C produced bracts with high colour scores, whereas transfer from 15 - 21°C tended to reduce bract colour at the end of production.

  In Sonora, Spotlight and Lilo plants grown at 21°C, the use of supplementary light appeared to offset bract fading seen in the ambient / shaded treatments though this was not statistically significant. Freedom naturally produced larger, paler bracts than the other varieties in the trial and temperature effects were most noticeable in this variety.

- **Foliage quality (score 0 [worst] - 5 [best]; Appendix 3, Fig 8):** Both Lilo and Sonora produced uniformly high quality foliage across all temperature treatments. The only notable (but not statistically significant) reduction in foliage quality in these varieties was seen in the shaded treatments. Foliage quality was generally poorer and more variable in Freedom and Spotlight than in the other varieties. In Freedom, plants that were either grown at 15°C or finished at 15°C (21 - 15°C transfer) had higher quality foliage than in the other temperature treatments. Overall, shading reduced foliage quality (but only slightly in Lilo and Sonora), and supplementary lighting produced marginal benefits in terms of foliage quality in all varieties except Freedom.

- **Cyathia number / break and stage of development at marketing (Appendix 3, Fig 9a - d):** Cyanthia development was not directly related to stage of bract colouration and the longevity of cyathia post-harvest were dependent both on light and temperature. In plants grown cool from week 43, cyathia development was significantly delayed for a given bract colour, and this delay was further enhanced by shading. In warmer treatments, cyathia development progressed much quicker, so that in varieties with a shorter response time, both pollen and stigmas were showing at marketing (Appendix 3, Fig 9a – d).

  Numbers of cyathia per break were also significantly affected both by temperature and light level. Both high temperaure (Table 3) and low light (Table 4) significantly reduced the number of cyathia / break when compared to the 15 and 18°C treatments (P = 0.05). There was no significant effect of late-season reciprocal transfers between 15 and 21°C on cyathia number at marketing.

  Although it was not possible to determine the proportion of cyathia which had dropped due to natural ageing from those which had aborted prematurely, (they both left similar abscission scars), it was clear that, where premature abortion was identified, it was predominantly in the shaded treatments, and in the temperature transfer and high temperature treatments. Shading markedly reduced the numbers of cyathia reaching maturity through premature abortion. Spotlight was the slowest to develop cyathia, and no pollen records were obtained for this variety across all treatments before 10/12/97 when records ceased. Of the four varieties tested, Lilo produced, on average 70% more cyathia / bract than Sonora or Spotlight, and 144% more than in Freedom. In Freedom, shading had a more marked effect on cyathia development than in the other varieties, with only half the number of cyathia produced in the shaded treatment compared to the ambient or supplementary light treatments. In Lilo, it was clear that shading had a marked effect in delaying cyathia development compared to the other lighting treatments.

  The schematic diagram in Figure 1, p**, shows how increasing temperature affects the interaction between bract size, bract colour and stage of cyathia development at marketing. The rate of cyathia development, changes in bract size, and loss of bract colour were all greater with increasing temperature.

- **Overall plant quality score (score 0 [unmarketable - 2 [grade 1], Appendix 3, Fig 10):** Of the varieties tested, Sonora (overall score = 1.766) and Lilo (overall score = 1.796) were judged on average as being of higher quality than Spotlight (1.725) and Freedom (1.704). Although there was no significant effect of variety on plant quality, there was an effect of shade, which significantly reduced (P = 0.05) plant quality scores (Table 4). In all varieties, quality was reduced both by shading and, to a lesser (not statistically significant) extent, by growing at higher temperatures for extended periods after initiation. In all varieties, cool-grown plants were judged to be of as high quality as the other temperature treatments within a given lighting treatment.

Table 3: Main effects of temperature on variables measured at the end of production.

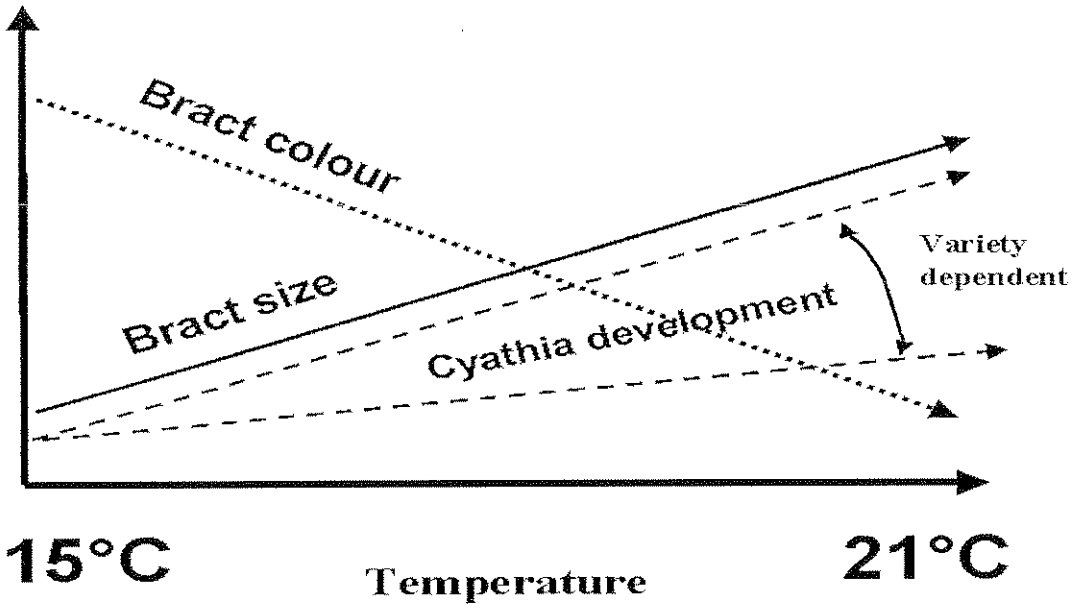
Temperature (°C)	Crop Duration (days)	Plant Height (mm)	Plant Diameter (mm)	Bract Leaf Area (mm^2)	Bract Colour Score	Number of Cyathia / Break
15	141.96	303.7	453.5	7392	4.87	15.52
18	131.33	311.6	466.4	11269	4.74	15.50
21	131.96	330.6	475.8	13092	3.98	11.25
15 – 21	130.08	310.3	448.8	10366	4.10	14.61
21 –15	134.92	330.6	477.4	12053	4.35	13.91
LSD (5%) (56 d.f.)	2.8	9.2	10.1	953	0.40	1.76

In each case, comparisons within variable are made against the 18°C temperature treatment

Table 4: Main effects of light level on variables measured at marketing.

Light level	Duration (days)	Mean number of cyathia / break	Plant quality score
Low (shaded)	138.93	11.41	1.53
Ambient	131.80	14.90	1.83
High (suppl: + 3 klx)	131.43	16.16	1.88
LSD (5%) (2 d.f.)	3.71	1.74	0.21

Figure 1: **Schematic diagram showing how bract colour, bract leaf size and rates of cyathia development change with temperature.**



3.1.1.1 *Marketing data - general observations:*

- Of the four varieties tested, Freedom was the most markedly affected across the treatments and produced, on average, poorer quality plants than the other three varieties included in this trial.

- Cool growing post-initiation generally increased foliage and bract colour and quality, but Spotlight produced rather small bracts when grown at cooler temperatures. In Spotlight, this problem of small bract production at cool finishing temperatures could be partially offset by late-season transfer into higher temperatures. Sonora and Lilo produced consistently high quality plants over the range of treatments imposed, but the combination of warm temperatures and shading late in production still markedly reduced quality even in these varieties.

- Cyathia number and stage of development were strongly affected both by temperature and light, with cool-growing delaying cyathia development at the standard marketing stage (relative to bract colouration). This resulted in cool-grown plants having more intact cyathia at harvest than in comparable plants finished at 21°C, with the potential benefits of continued cyathia development during shelf-life. Low light levels during production restricted the numbers of cyathia reaching maturity, with many immature buds being aborted and dropped before marketing.

- Crop duration was significantly longer in plants grown at 15°C than at 18 or 21°C. The delay of 10 days was much reduced when compared to whole-season cool-grown crops (1995 & '96 trials). Shading enhanced the delay associated with cool-growing.

- Reduced production delays, combined with enhanced quality of bract and foliage, and cyathia longevity may make late-season cool-growing a more attractive approach for maintaining quality at this time of year than extended season cool-growing techniques.

3.1.1.2 *Effect of temperature * light treatment on shelf-life: some observations (Appendix 4, figures 1 – 20)*

All plants for this observation were taken at the "standard marketing" stage based bract colour. In a small supplementary observation (not statistically analysed), the interaction between tempertature and light during production on post harvest performance was considered. Data is presented in the graphs in Appendix 4, and clearly shows (at marketing, plants from each treatment were taken from each plot into shelf-life. This part of the shelf-life work was not strictly a specific objective of the trial, but the effect of interactions between temperature and light during production on post-harvest performance are presented as additional information (not statistically analysed), and they clearly show the shelf-life trends for each variety as influenced by treatment during production.

It must be noted at this stage, that these data are for plants marketed at what is currently considered to be their "standard marketing stage" (based on bract colour), and this does not relate directly to the marketing stages as defined in section 3.1.2 below. With this in mind, the standard market stage used for this part of the work would lie somewhere between 10 and 20 days after 'Stage 1' as defined for work in section 3.1.2.. Attempts to make direct comparisons between data sets are not strictly valid, but the trends from both data sets do support each other.

- ***Green leaf loss (Appendix 4.1-4.4):*** The data indicate no marked effects of temperature or light environment on the rates of leaf loss post-harvest. There was an indication that transfer of plants from 15 – 21°C late in production may promote increased rates of green leaf loss when compared to the straight 21°C treatment, particularly in Lilo (Appendix 4, Fig 4.3). The reciprocal transfer treatment had no adverse effects on leaf loss or quality. Overall, leaf loss was slightly greater in Sonora than in the other varieties tested.

- ***Foliage deterioration (Appendix 4.5-4.8):*** Plants produced under low-light conditions tended to have paler leaves at marketing and post-harvest, foliage from low-light plants deteriorated more quickly than in plants from the higher light environments.

- ***Bract loss (Appendix 4.9-4.12):*** In all treatments, bract retention was good until about 24 d post de-sleeving. After this time, bract loss was slightly elevated in plants finished at cooler temperatures. These data correlate with the market stage data set (section 3.1.2), in which plants marketed later tended to have higher bract losses in the cool-finished than warmer-finished product. Data presented here from "standard marketing" would represent marketing stage 2 – 3 for the work presented in 3.1.2. There were no consistent effects of light level during production on bract loss during shelf-life.

  Of the varieties tested, Lilo performed better, in terms of post-harvest bract retention, than Spotlight, Freedom and Sonora. It should be noted however that in Sonora, which produced many small bract leaves, the loss of a bract leaf had far less negative visual impact on the plant than in Freedom, a variety with fewer, larger bracts future trials may attempt to differentiate between large and small bracts when assessing loss during shelf-life.

- ***Bract deterioration (Appendix 4.13-4.16):*** Bracts in cool-finished plants started shelf-life with more intense colour than in plants from the warmer treatments. There was a reduction in bract colour in plants grown under low-light conditions. This was particularly noticeable in Freedom, where both bract size and colour were more markedly affected by temperature / light than in the other varieties.

  Bract colour score remained higher in cool-finished plants for longer during shelf-life than in the other treatments, but did decline steadily throughout the shelf-life period.

- ***Cyathia development / loss during shelf-life (Appendix 4.17-4.20):*** Figures 4.17 – 4.20 clearly show how both numbers of cyathia, and cyathia longevity during shelf-life were promoted in plants which were cool-finished at 15°C. This was due mainly to the presence of many cyathia at stage 1 (green bud) in cool-finished plants at marketing, with these buds developing further during shelf-life. In warmer-finished plants, a high proportion of the cyathia were already at stages 3+, with little prospect of continued development and retention during shelf-life. Low-light levels during production reduced the numbers of cyathia reaching

maturity, with many cyathia being aborted and dropped prematurely during production. The benefits of cool-finishing for post-harvest cyathia longevity were most clearly marked in the varieties with longer response times i.e. Spotlight and Sonora.

3.1.2 Effect of stage of plant development at marketing on performance during shelf-life (Appendix 5: Figs. 5.1 - 5.8)

Plants were removed from the production area into shelf-life at three stages of development as previously described in the methods section. The earliest marketing stage was determined as the time when bracts were fully coloured except for one bract on the upper whorl. The second and third market stages were taken 10 and 20 days later respectively. On each occasion, the stage of development of cyathia on a tagged break was determined as described above (stages 1(green bud) – 5 (pollen showing and stigma open)), together with records of foliage and bract losses and quality / colour deterioration during shelf-life.

Statistical analysis of variance was carried out for data at the start of shelf-life, at de-sleeving and 10, 24, 31 and 45 days after de-sleeving. Data for each variable were compared 31 days after de-sleeving to represent an acceptable period for the consumer.

Effects of marketing stage and temperature on green leaf loss: Overall, Lilo and Freedom (Appendix 5, Figs. 5.3 – 5.4) lost significantly fewer leaves than Sonora or Spotlight (Appendix 5, Figs. 5.1 – 5.2, Table 5). There was little effect of marketing stage on the rates of leaf loss in Lilo or Freedom and no significant temperature effects. However, in Spotlight and Sonora, the rate of leaf loss increased with delayed marketing. When marketed early, cool-finished plants retained their foliage better than plants finished at 18 or 21°C, but when marketed later, there was an increase in leaf loss in the 15 and 18°C pots in comparison to the 21°C treatment. The high leaf losses in Spotlight correlated with the incidence of *Botrytis* in the 15 and 18°C treatments of this variety.

Table 5: Cumulative leaf loss in Lilo, Freedom, Spotlight and Sonora after 31 d after de-sleeving.

Variety	Lilo	Freedom	Spotlight	Sonora
Leaf loss	8.28	7.81	20.83	21.51

LSD (5 %) = 12.12 (56 d.f)

Effects of marketing stage and temperature on bract loss: In all varieties, bracts remained intact for longer in plants marketed early, with no significant effect of temperature (Table 6). As marketing was progressively delayed, there were marked increases in the rates of bract loss, and by the latest marketing stage bract losses were highest in plants finished at 15 or 18°C and especially in Spotlight and Sonora. Although later marketing of plants finished at higher temperature resulted in better post-harvest bract life, this must be offset against the negative factors such as enlarged and faded bracts that develop under these conditions (see marketing section 3.1.1.1).

Table 6: Effect of variety, temperature and market stage on post-harvest cumulative bract loss 31 days after de-sleeving.

		Market stage		
Variety	**Temperature**	**Stage 1** (early)	**Stage 2** (Stage 1 + 10 d)	**Stage 3** (Stage 1 + 20 d)
Freedom	15°C	2.00	1.50	13.75
	18°C	0.25	2.50	5.50
	21°C	0.00	2.50	8.25
Lilo	15°C	4.25	22.75	24.00
	18°C	2.25	9.25	15.50
	21°C	6.50	4.25	4.00
Spotlight	15°C	9.25	30.75	25.25
	18°C	15.25	24.50	37.25
	21°C	9.50	20.50	12.50
Sonora	15°C	12.25	10.00	44.25
	18°C	4.75	4.25	18.49
	21°C	3.25	5.25	22.74

When comparing effects of temperature (same variety * market stage) LSD (5%) = 16.7; 17 d.f.
When comparing effects of Market stage (same temperature * variety) LSD (5%) = 10.37; 22 d.f.
When comparing variety means (same market stage * temperature) LSD (5%) = 16.34; 16 d.f.

Effect of temperature * market stage on cyathia development / loss during shelf-life(Appendix 5; Figs. 5.5 – 5.8; Plates 6 & 7): At a given stage of bract colour development, in all varieties, cyathia development was markedly affected by growing temperature, with warm-finished plants having more advanced cyathia at marketing than cool-finished plants (at a comparable point of bract colouration). This means that when bracts are fully coloured in a warm-finished plant, the cyathia may all be open, whereas in a cool-finished plant, at the same stage of bract colour, the

cyathia will be closed or just starting to open. Therefore, the potential for continued cyathia development / retention post-harvest may be greater in plants finished at cooler temperatures.

- There was no significant effect of market stage on numbers of cyathia per break (within variety * temperature; Table 7).

- In Sonora and Spotlight, plants in the 21°C treatment had significantly fewer cyathia per break than those grown at 15 or 18°C (Table 7; no cyathia present in Lilo or Freedom by this stage).

- At all marketing stages and in all temperature treatments, Sonora and Spotlight had significantly more cyathia remaining on the breaks 31 d after de-sleeving than Lilo or Freedom.

- On average, Lilo had the most advanced cyathia at each marketing stage, followed by Sonora, Freedom and with Spotlight showing least developed cyathia.

- At any marketing stage, increased temperature during the final phase of production resulted in advanced cyathia development and reduced post-harvest cyathia longevity.

From the graphs in Appendix 5, it is clear that cyathia development in Sonora, Spotlight and Freedom was slower at all temperatures (and market stages) than in Lilo. In Spotlight and Freedom, cyathia rarely reached stage 3 (pollen showing), even in the latest market stage. In Sonora and Spotlight, cyathia development was increased and sustained throughout shelf-life.

Although Lilo produced many cyathia by the earliest marketing stage, because they were already at stage 3+ by this time, cyathia were rapidly lost during shelf-life without new developing buds coming in to replace them, especially in plants finished at higher temperatures.

Table 7: Effects of temperature and market stage on mean numbers of cyathia per break remaining 31 days after de-sleeving

Variety	Temperature	Market stage		
		Stage 1 (early)	Stage 2 (Stage 1 + 10 d)	Stage 3 (Stage 1 + 20 d)
Freedom	15°C	8.50	0.00	4.00
	18°C	3.00	2.00	0.00
	21°C	0.50	0.00	0.00
Lilo	15°C	0.00	0.00	1.50
	18°C	4.00	0.50	2.00
	21°C	0.50	1.00	0.00
Spotlight	15°C	22.00	22.50	19.50
	18°C	12.00	4.50	14.00
	21°C	7.50	3.50	9.00
Sonora	15°C	21.00	22.50	19.50
	18°C	16.00	16.00	23.99
	21°C	8.50	6.00	9.25

When comparing effects of temperature (same variety * market stage) LSD (5%) = 8.58; 21 d.f.
When comparing effects of Market stage (same temperature * variety) LSD (5%) = 7.924; 22 d.f.
When comparing variety means (same market stage * temperature) LSD (5%) = 7.69; 30 d.f.

Cyathia production in Freedom was rather poor, with relatively few present at any marketing stage. The cyathia that were present at marketing rarely developed beyond stage 2, and were quickly lost during shelf-life, especially in plants finished at higher temperatures.

Effect of temperature * market stage on foliage colour score during shelf-life: There were no significant effects of temperature or market stage on foliar colour score.

Effect of temperature * market stage on bract colour score during shelf-life:

(i) At the start of shelf-life

- In all varieties and at all market stages, there were significant reductions in bract colour in plants grown in the 21°C treatment compared to either 15 or 18°C (Table 8). Cool-finished plants had better bract colour than warm-finished plants (particularly for Freedom).

- Although there were visible reductions in bract colour with delayed marketing, these were not statistically significant within the constraints of the current trial.

Table 8: Effects of temperature and market stage on bract colour score at the start of shelf-life.

Variety	Temperature	Market stage		
		Stage 1 (early)	Stage 2 (Stage 1 + 10 d)	Stage 3 (Stage 1 + 20 d)
Freedom	15°C	5.00	5.00	5.00
	18°C	3.00	3.00	3.00
	21°C	2.50	3.00	2.00
Lilo	15°C	4.50	3.50	3.50
	18°C	3.25	3.50	3.00
	21°C	3.00	3.00	3.00
Spotlight	15°C	5.00	5.00	4.25
	18°C	5.00	3.50	4.75
	21°C	3.50	3.00	3.00
Sonora	15°C	5.00	5.00	4.25
	18°C	4.50	4.75	5.00
	21°C	3.00	3.00	3.50

When comparing effects of temperature (same variety * market stage) LSD (5%) = 0.776; 32 d.f.
When comparing effects of Market stage (same temperature * variety) LSD (5%) = 0.845; 23 d.f.
When comparing variety means (same market stage * temperature) LSD (5%) = 0.796; 31 d.f.

(ii) 31 days after de-sleeving

- In Freedom, there were significant reductions in bract colour by 31 days after de-sleeving in the 21°C treatment at all market stages compared to 15 or 18°C. In the other varieties, significant reductions in bract colour due to increased temperatures, were only seen in plants marketed at stages 2 or 3 (Table 9).

- Therefore cool-finished plants retained better bract colour during shelf-life when marketed late than plants finished at 21°C.

Definition of optimal market stage:

- The precise definition of marketing stage in varieties cultured under different temperatures is complicated by the fact that cyathia development in relation to bract colour changes with production temperature. For this reason it is not possible to define a single stage of development at which each variety should be marketed. It is possible however to illustrate how bract colour, bract size and cyathia development all change with temperature and market stage so that for varieties with particular characteristics, the optimal marketing stage can be gauged.

Table 9: Effects of temperature and market stage on bract colour score 31 d after de-sleeving.

Variety	Temperature	Market stage		
		Stage 1 (early)	Stage 2 (Stage 1 + 10 d)	Stage 3 (Stage 1 + 20 d)
Freedom	15°C	2.75	3.50	3.50
	18°C	2.50	2.00	2.75
	21°C	1.00	1.50	1.25
Lilo	15°C	3.50	3.00	3.25
	18°C	3.25	3.00	2.75
	21°C	3.00	2.50	1.50
Spotlight	15°C	2.25	2.50	2.75
	18°C	2.75	2.75	1.75
	21°C	1.75	1.75	1.75
Sonora	15°C	2.50	2.50	2.75
	18°C	2.75	2.75	2.50
	21°C	2.50	2.25	2.13

When comparing effects of temperature (same variety * market stage) LSD (5%) = 0.857; 28 d.f.
When comparing effects of Market stage (same temperature * variety) LSD (5%) = 0.730; 22 d.f.
When comparing variety means (same market stage * temperature) LSD (5%) = 0.900; 22 d.f.

- Figure 2 (page 38) shows how bract colour fades as bract size increases in plants finished warm, whereas size and colour remain stable in plants finished at lower temperatures. Although cyathia development varies between varieties (i.e. more advanced in Lilo than the others), warm-finished plants have relatively advanced cyathia development compared to cooler finished plants and this feeds through to reduced post-harvest cyathia retention.

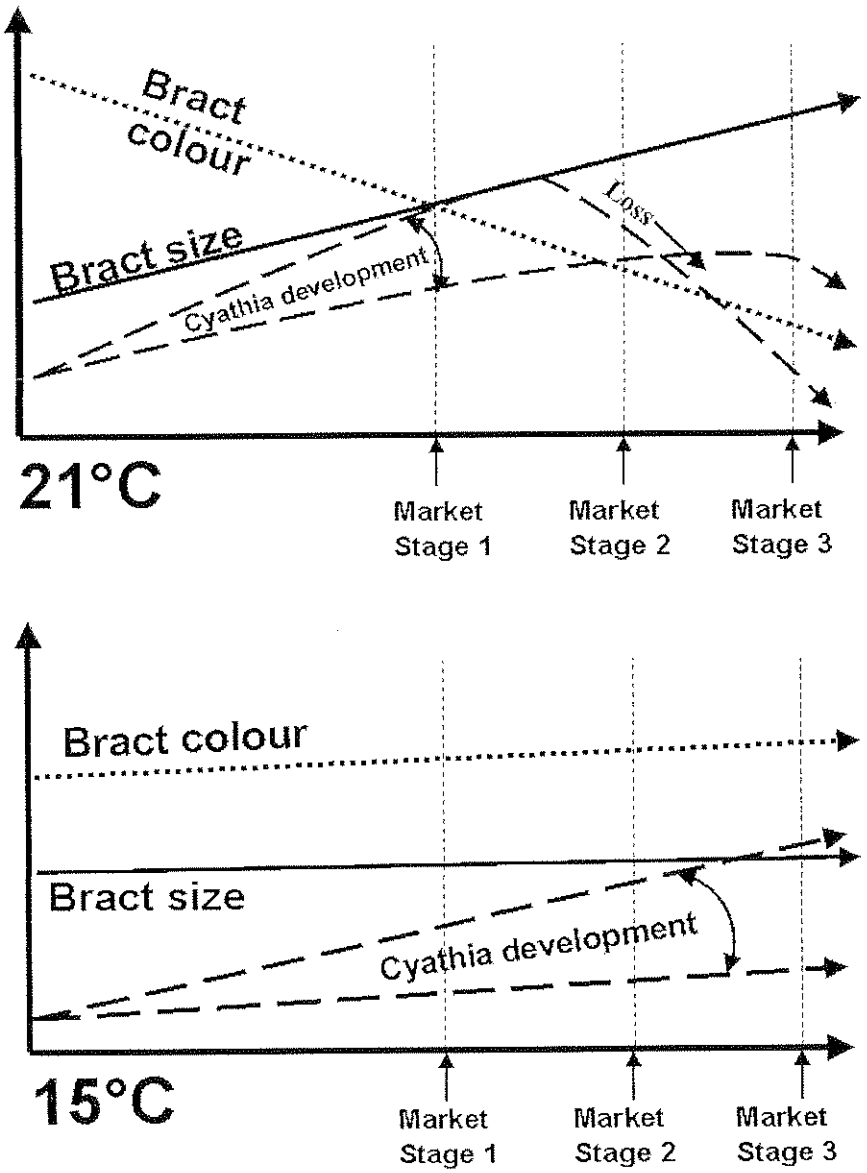
- For each variety there is a trade-off between bract size, colour, stage of cyathia development and post-harvest longevity. In varieties such as Spotlight, which have small bracts it may be preferable to increase the temperatures later in production to enlarge the bracts. This may reduce bract colour intensity and also advance cyathia development. In Spotlight, where cyathia development is slow, increased temperature at the end of production may not have any deleterious effects. In Freedom, it may be preferable to finish cool to slightly reduce bract size and enhance colour without detrimental effects on cyathia.

- In all cases the data demonstrate the advantages of early marketing in order to retain plant quality and "completeness" (i.e. with cyathia in-tact) for longer post-harvest.

- Cool-finished plants retained better bract colour during shelf-life when marketed late than plants finished at 21°C.

- Finishing the crop cool had no deleterious effects on post-harvest performance in pots marketed early. However, if marketed late, there was evidence that plants held-cool for prolonged periods may suffer from increased leaf and bract losses later on post-harvest (when compared to warm-finished plants).

Figure 2: Schematic diagram showing how bract colour, bract leaf size and rates of cyathia development change with temperature and marketing stage.



3.2 Commercial grower new variety trial

3.2.1 Production phase data

14 cultivars were grown at each of four sites. Details in Tables 10 - 12 give cultural details for production at each site.

Table 10 : Potting and pinching regimes applied to varieties at each site

Site	1	2	3	4
Potting Week	32	30	32	31
Pot Size cm	13	13	13	13
Compost	Sinclair Poinsettia	Sinclair Poinsettia	Bullrush	Bullrush
Pinch Week	33	32	34	32
Spacing half	37	33	36	36
Spacing final	38 10.5 m^2	37 10 m^2	38 11 m^2	38 10m^2
Lighting day extension/night break	None	to week 31	None	None
Assimilation	None	None	None	None

Table 11: Temperature regime at each site with time during production

Site	1		2		3		4	
a	day wk 32	18°C	wk 30	20°C	wk 32	17°C	wk 31	20°C
	night	19°C		20°C		18°C		20°C
	vent	20°C		22°C		20°C		22°C
b	day wk 34	17°C	wk 40	18°C	wk 40	17°C	wk 42	19°C
	night	18°C		18°C		18°C		20°C
	vent	19°C		20°C		20°C		22°C
		+ 4° drop						
c	day wk 46	17°C	wk 43	17°C	wk 43	18°C	wk 43	18°C
	night	18°C		18°C		19°C		18°C
	vent	19°C		19°C		20°C		21°C
				4°C drop				
d	day wk 48	20°C	wk 47	20°C	wk 47	16°C	wk 45	17°C
	night	21°C		20°C		17°C		18°C
	vent	22°C		22°C		19°C		19°C
e	day wk 49	17°C	wk 49	17°C	wk 49	15°C	wk 46	16°C
	night	18°C		18°C		16°C		16°C
	vent	19°C		20°C		18°C		18°C
CO_2	-	None		450 ppm		None		None

Table 12 : Cycocel applications for each variety across sites

		1	2	3	4
PGR Application		ccc 46%	ccc 62%	ccc 62%`	ccc 46%
Rate		2.0 ml/l	1.5 ml/l	1.5 ml/l	1.0 ml/l
Variety:					
1.	Christmas Carol	None	x 15	x 1	x 7
2.	Coco Red	None	x 14	x 3	x 7
3.	Lilo	x 2	x 14	x 4	x 7
4.	Malibu	None	x 15		x 7
5.	Santa Claus	x 4	x 15	x 4	x 7
6.	Sonora 'a'	None	x 14	x 1	x 7
7.	Sonora 'b'	None	x 14	x 1	x 7
8.	Spotlight	-	-	-	-
9.	Tabaluga	None	x 14	x 1	x 7
10.	White Christmas	None	x 15	x 1	x 7
11.	Xenia	None	x 15	x 3	x 7
12.	457	x 1	x 15	x 4	x 7
13.	746	-	-	-	-
14.	2969	None	x 14	x 3	x 7

Measurements after pinching:

a) Height (cm), from the base to top of cutting.

b) No. of shoots with 2 leaves or more.

c) All cuttings were stopped 6-7 leaves.

Comments

All varieties produced good mean number of shoots, the highest being the 2 Sonora varieties and the lowest the Dummen coded number 457. The mean number of shoots was 6.7. Height of stopping was similar on all sites 2, 3 and 4 but where a week's delay in potting through transportation occurred for site 1the height had risen to 6 cm. The week's delay did mean that the number of plants in some varieties was reduced due to losses.

Foot Notes:

1. The varieties to site 1 were delayed one week in transport.

2. The variety Spotlight was not delivered.

3. The variety 746 was mixed and was not recorded.

4. The main differences in production were that on site 2 CO_2 was given to 450 ppm and night break lighting was given to week 31, whereas on all other sites no night break lighting was applied. Cycocel application on sites 1 and 4 were at 46% and 62% to sites 2 and 3. On site 2 Cycocel was applied as a drift.

3.2.2 Marketing data: Variety trial

Variety descriptions close to marketing:

1. ***Christmas Carol - Selecta:*** Tall upright habit, thick stems, foliage light green and some leaf yellowing. Bract colour salmon orangey pink. Cyathia medium in size. Fewer than average stars (**quality score = 7.0**).

2. ***Coco Red - Dummen:*** Plants tall & upright, foliage dark green, oak leaf with a little lower leaf drop. Bracts large, well above the foliage with a slight rippling. Colour dull GPO red. Cyathia medium to small, undeveloped, uniformity reasonable, a good packing variety with high score for quality (**8.5**).

3. ***Lilo - Fischer:*** Plants tall and variable in habit. Foliage dark green, oak leaf, no leaf yellowing. Bracts GPO red. On average > 5 stars of good size but with high incidence of splitting. Cyathia large and well developed (**quality score = 6.5**).

4. ***Malibu - Dummen:*** This variety has spreading growth and was perceived as being hard to sleeve. Foliage dark green, oak leaf to oviate leaves. Little lower leaf loss. Bracts dull GPO red, flat, prominent. Cyathia small and undeveloped. Some variability (**quality score = 5.75**).

5. ***Santa Claus - Selecta:*** Tall & upright but tends to produce odd sideways-bending branches and smaller than average bract stars. Foliage light green, oviate. Lower leaves good. Bracts velvety red. Cyathia well developed (**quality score = 5.0**).

6. ***Sonora – selection 'a':*** Upright habit, but with some shoots extending outwards which would cause loss when packing. Foliage dark green, oak leaf. This variety produced the highest number of shoots, with many small shoots deep within the canopy which may be susceptible to *Botrytis*. Bracts bright red, oak leaf. Bracts held low in leaves. Cyathia underdeveloped (**quality score = 6.75**).

7. ***Sonora – selection 'b':*** Compact upright habit (shortest variety in the trial), but with some shoots going off at right angles. Foliage oak leaf, dark green. Bracts held in leaves. Cyathia medium sized and not advanced (**quality score = 6.75**).

8. ***Spotlight - Dummen:*** Not supplied.

9. ***Tabaluga - Dummen:*** Habit variable branches spreading with poor packing qualities. Foliage mid green, leaves oval to oak leaf. Bracts velvet pink red, small and variable in size. Cyathia numerous, well developed with some splitting (**quality score = 5.50**).

10. ***White Christmas - Selecta:*** Compact and broad habit : branches wide, not upright, pear shaped. Bracts creamy-white and small. Cyathia large. Some leaf yellowing and leaf drop. May need more light or higher temperature (**quality = 4.75 [lowest]**).

11. ***Xenia - Dummen:*** Tall, upright habit, good for sleeving. Foliage mid to dark green, oak leaf. Bracts bright red, oak leaf shaped. Cyathia small, no flowers open. Flat top (**quality score = 7.25**).

12. ***457 - Dummen:*** Tall upright habit, good to sleeve. Foliage dark green, oak leaf. Bract dull GPO red, rippled. Fewer than average breaks and bract stars produced. Cyathia large, just opening, uniformity fairly good but some lower leaf yellowing (**quality score = 8.00 [highest]**).

13. ***746 - Dummen:*** Mixed and not recorded.

14. ***2969 - Dummen:*** Tall and vigorous with strong branches. Average number of bracts with many poorly developed. Foliage good at base, irregular in uniformity (**quality score = 6.50**).

Tables 13 - 15 summarise data collected at the 4 grower holdings prior to dispatch to HRI-Efford at / close to marketing.

Although it was not possible to formally analyse the data collected at the grower holdings, data tables have the standard deviations of the means in brackets (SD). These represent the variability of a variety across sites (along rows), and between varieties at any given site (down columns). The greater the SD, the more variable the performance. For statistical analysis of the new variety data, the data from variables measured at sleeving on arrival at Efford have been statistically analysed (see section 3.2.2) and can be used in conjunction with the current data.

Plant height (Table 13):

- The mean total height throughout the 4 sites was very similar and ranged from just under 28 cm to 30 cm. Of the varieties on trial, Sonora, Tabaluga and White Christmas were shortest, with Lilo, Santa Claus, Xenia, 457 and 2969 all taller than the average. Lilo was the most variable, with 2969 the most consistent across sites. Least variation in height was seen on site 2 where the highest frequency of growth retardant was used.

Plant diameter (Table 13):

- The most spreading plants were grown at site 4 and the smallest on site 1 (the latter may be due to transportation problems of the cuttings i.e. 7 days delay and the infrequent use of CCC). Of all varieties, Santa Claus had on average, the greatest diameter. In general, the larger varieties (Santa Claus, Lilo, Malibu and Xenia) were also very variable in diameter. Christmas Carol produced the narrowest plants, but the most consistent and least variable varieties (wrt. plant diameter) were Coco Red and 457.

Number of stars (Table 14):

- The highest number of stars were on site 4, with sites 2 and 3 very similar. Of the varieties, Sonora (F), White Christmas, Tabaluga and Xenia produced a higher than average number of stars, with fewest on Christmas Carol, Coco Red and 457.

Star diameter (Table 14):

- Although the average star diameter appeared similar across sites, there was considerable variation within varieties across sites. Coco Red consistently produced the largest bract stars (with little variability), and although 457 also produced large stars, it was quite variable. White Christmas and Tablauga produced the smallest stars, but of these two, Tabaluga was highly variable.

Number of shoots (Table 15):

- The total number of shoots was similar in sites 2-4 and highest on site 1 where the cuttings were not stopped until they were 6 cm, as against an average of just of 4.7 on the other 3 sites. Sonora (both sources) and Tabaluga all produced very high numbers of shoots, with variety 457 producing least shoots across the trial.

Quality and marketing scores (Table 15):

- On quality each point reflected a down-grade in quality from 10. The marketing figure each down-graded point from 10 was equivalent to 4 days extra to the marketing period. Although there were small differences in the mean quality at each site, the variability in quality scores across sites indicate that there was no overall benefit of growing at any given site. Of the varieties on trial , Coco Red, 457, Xenia and Christmas Carol all produced high quality plants, and of these, Xenia was least variable across sites. On average, White Christmas, Santa Claus, Tabaluga and Malibu were perceived as having the poorest quality across sites. The same trends were seen in the marketability scores, with Coco Red, Lilo and 457 judged as best and White Christmas the worst. It should be noted that White Christmas has a slower response than the other varieties and this was a major factor affecting its score for marketability at the time of recording.

Table 13 Commercial Trial Results

Variety and Source		Height (cm) Site 1	Site 2	Site 3	Site 4	Mean	Mean Plant Diameter (cm) Site 1	Site 2	Site 3	Site 4	Mean
1. Christmas Carol	S	25.2	29.9	27.6	30.3	**28.3 (2.36)**	35.9	41.3	40.4	49.4	**41.8 (5.62)**
2. Coco Red	D	31.8	30.4	27.6	26.9	**29.2 (2.31)**	43.0	48.4	43.8	46.1	**45.3 (2.43)**
3. Lilo	F	30.8	33.8	29.4	37.5	**32.9 (3.59)**	39.4	52.3	45.8	56.7	**48.6 (7.57)**
4. Malibu	D	24.9	29.3	26.0	28.0	**27.1 (1.97)**	39.4	54.1	47.3	54.0	**48.7 (6.97)**
5. Santa Claus	S	29.7	31.9	28.9	33.5	**31.0 (2.09)**	43.9	53.9	48.1	58.5	**51.1 (6.41)**
6. Sonora	'a'	26.7	26.8	25.4	31.1	**27.5 (2.48)**	39.4	48.9	48.7	53.5	**47.6 (5.91)**
7. Sonora	'b'	21.6	28.3	24.6	26.1	**25.2 (2.81)**	35.0	42.1	43.9	48.9	**42.5 (5.75)**
8. Spotlight	D	-	-	-	-	- - -	-	-	-		
9. Tabaluga	D	25.4	27.8	27.5	24.3	**26.3 (1.68)**	41.0	48.4	45.4	50.2	**46.3 (4.02)**
10. White Christmas	S	23.2	29.7	26.0	28.1	**26.8 (2.81)**	37.1	47.5	44.1	50.2	**44.7 (5.66)**
11. Xenia	D	29.9	31.4	32.2	28.3	**30.5 (1.72)**	38.7	55.1	47.7	49.0	**47.6 (6.77)**
12. 457	D	31.8	31.1	31.6	26.2	**30.2 (2.67)**	40.4	45.5	45.4	40.3	**42.9 (2.95)**
13. 746	D	-	-	-	-	- - -	-	-	-		
14. 2969	D	30.5	29.8	32.0	28.7	**30.3 (1.04)**	40.9	47.4	49.9	49.9	**47.0 (4.25)**
Mean		**27.6**	**30.0**	**28.2**	**29.0**	**28.7 (1.38)**	**39.5**	**48.7**	**42.2**	**50.6**	**45.3 (5.26)**
(S.D.)		**(3.54)**	**(1.91)**	**(2.62)**	**(3.61)**	**(2.27)**	**(2.63)**	**(4.49)**	**(2.63)**	**(4.80)**	**(2.82)**

Table 14 Commercial Trial Results

Variety and Source		Number of Stars					Diameter of star (cm)				
		Site 1	Site 2	Site 3	Site 4	Mean	Site 1	Site 2	Site 3	Site 4	Mean
1. Christmas Carol	S	5.3	4.3	4.2	5.9	**4.93 (0.82)**	22.7	19.6	22.4	23.4	**22.0 (1.67)**
2. Coco Red	D	5.8	4.5	4.3	5.2	**4.95 (0.69)**	22.9	22.9	22.6	23.7	**23.0 (0.47)**
3. Lilo	F	5.5	4.0	5.2	6.0	**5.18 (0.85)**	22.0	23.0	21.1	23.1	**22.3 (0.94)**
4. Malibu	D	5.7	5.2	4.9	6.0	**5.45 (0.49)**	19.9	22.3	20.7	23.1	**21.5 (1.46)**
5. Santa Claus	S	5.8	4.8	4.2	6.2	**5.25 (0.91)**	18.6	16.4	18.9	19.3	**18.3 (1.30)**
6. Sonora	'a'	6.1	5.8	4.9	6.3	**5.78 (0.62)**	20.6	19.9	21.9	23.9	**21.6 (1.76)**
7. Sonora	'b'	4.6	5.2	4.6	6.1	**5.13 (0.71)**	17.6	19.9	20.4	21.6	**19.9 (1.68)**
8. Spotlight	D	-	-	-	-	-	-	-	-	-	-
9. Tabaluga	D	6.7	5.8	4.3	5.7	**5.63 (0.99)**	20.1	18.0	10.0	21.3	**17.4 (5.09)**
10. White Christmas	S	6.1	5.9	4.8	6.1	**5.73 (0.62)**	16.9	16.5	18.3	18.4	**17.5 (0.97)**
11. Xenia	D	5.5	6.0	5.0	5.8	**5.58 (0.43)**	21.0	20.8	20.0	23.4	**21.3 (1.47)**
12. 457	D	5.0	3.5	6.3	4.9	**4.93 (1.14)**	22.7	23.5	26.9	18.4	**22.9 (3.50)**
13. 746	D	-	-	-	-	-	-	-	-	-	-
14. 2969	D	5.6	4.0	5.0	6.3	**5.23 (0.97)**	19.0	19.3	21.2	21.0	**20.1 (1.14)**
Mean		**5.6**	**4.9**	**4.8**	**5.9**	**5.3 (0.53)**	**20.3**	**20.2**	**21.2**	**21.7**	**20.9 (0.72)**
(S.D.)		**(0.54)**	**(0.86)**	**(0.58)**	**(0.43)**	**(0.31)**	**(2.03)**	**(2.43)**	**(3.93)**	**(2.06)**	**(2.00)**

Table 15 Commercial Trial Results

Variety and Source		Total Shoots					Quality Score at Marketing					Marketability Score				
		Site 1	Site 2	Site 3	Site 4	Mean	Site 1	Site 2	Site 3	Site 4	Mean	Site 1	Site 2	Site 3	Site 4	Mean
1. Christmas Carol	S	7.1	5.9	5.9	6.8	6.43 (0.62)	7	7	8	6	7.00 (0.82)	8	6	8	6	7.00 (1.15)
2. Coco Red	D	8.1	6.2	5.7	5.9	6.48 (1.10)	7	9	8	9	8.25 (0.96)	9	10	7	9	8.15 (1.26)
3. Lilo	F	6.6	5.5	6.4	7.0	6.38 (0.63)	8	6	7	5	6.50 (1.29)	9	9	8	8	8.50 (0.58)
4. Malibu	D	6.8	6.8	6.5	6.9	6.75 (0.17)	7	4	5	7	5.75 (1.50)	6	6	5	8	6.25 (1.26)
5. Santa Claus	S	7.6	7.0	6.4	6.5	6.88 (0.55)	4	4	6	6	5.00 (1.15)	5	4	6	5	5.00 (0.82)
6. Sonora	'a'	9.1	8.0	8.7	7.4	8.30 (0.75)	7	6	7	7	6.75 (0.50)	7	5	7	7	6.50 (1.00)
7. Sonora	'b'	8.0	7.0	7.5	6.8	7.33 (0.54)	5	7	7	8	6.75 (1.26)	6	6	8	7	6.75 (0.96)
8. Spotlight	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9. Tabaluga	D	8.7	7.1	6.5	7.0	7.33 (0.95)	6	4	6	6	5.50 (1.00)	7	5	7	8	6.75 (1.26)
10. White Christmas	S	7.4	6.7	6.6	6.5	6.80 (0.41)	5	4	6	4	4.75 (0.96)	4	4	5	4	4.25 (0.50)
11. Xenia	D	7.1	7.1	6.7	7.0	6.98 (0.19)	7	7	7	8	7.25 (0.50)	8	7	6	8	7.25 (0.96)
12. 457	D	6.4	4.8	5.1	5.7	5.50 (0.71)	9	6	10	7	8.00 (1.83)	9	8	9	8	8.25 (0.58)
13. 746	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14. 2969	D	6.2	5.5	6.4	7.1	6.30 (0.66)	7	4	7	8	6.50 (1.73)	7	4	7	8	6.50 (1.73)
Mean		7.4	6.5	6.5	6.7	6.78 (0.43)	6.6	5.7	6.9	6.8	6.50	7.1	6.2	6.9	6.7	6.73
(S.D.)		(0.91)	(0.90)	(0.89)	(0.50)	(0.68)	(1.38)	(1.67)	(1.27)	(1.42)	(1.09)	(1.62)	(1.99)	(1.24)	(1.46)	(1.32)

3.2.3 Shelf-life data : New Varieties (supporting graphs in Appendix 6; 6.1 – 6.12)

Tables 16 - 18 present data for across-site means for the new varieties: (i) at sleeving (on arrival at Efford); (ii) on entry into shelf-life (Table 16); (iii) at de-sleeving (Table 17) and 31 days after de-sleeving (Table 18). 31 days was taken as an acceptable time at which to compare variety performance in line with retailer and consumer expectations of a month's home-life. In order to analyse the data, some variates have been square-root-transformed (srt). The transformed data are presented together with the means.

To study whether or not cumulative leaf loss was a good measure of performance during shelf-life, additional columns have been inserted in Tables 17 & 18, to investigate the percentage of leaf and bract losses per plant (calculated based on shoot (for calculation of leaf number) and star number (for bracts) collected in the marketing records). If plants had more foliage to begin with, then perhaps it would be able to tolerate higher leaf / bract losses during shelf-life before becoming "unacceptable". One would expect that different varieties might vary in the proportion of leaves they dropped, and this would impact on their visual acceptability.

To aid interpretation, the data have been used to generate a variety ranking order for each variable, with two overall ranks calculated as the mean rank across variables; the first for the ranks of the analysed data, and the second calculated using the percentage data generated as described in the paragraph above. The variety with the lowest rank was judged as performing best. It must be borne in mind that the rank data are only a general guide, and cannot be subjected to statistical analysis, and there are certain dangers with considering rankings of varieties, since equal weighting has been given to each variable, and this may not be appropriate. Appendix 6 should be referred to in conjunction with the following descriptions.

- Due to the delayed transport problems, material to site 1 was boxed for longer than was desirable. From the data, it is apparent that in all varieties, there were marked reductions in leaf and bract numbers and plant size, that could all be attributed to slow plant establishment. Site-to-site variability was, to some extent confounded by this additional factor, and makes interpretation of statistical analysis of resultsrelating to site-site variability difficult. For this reason, mean data are presented for each variety (across sites), and the main comparisons are between measured variables for each variety.

- **Leaf number / break and leaf loss during shelf-life:** Santa Claus and Lilo had significantly more leaves per break than the other varieties, with lowest leaf numbers per break in Coco Red, 457 and Sonora (Table 16).

  At de-sleeving (Table 17), leaf losses were lowest in Christmas Carol and Malibu, and significantly higher in both selections of Sonora and Tabaluga. The high losses in Sonora were due to *Botrytis* which had become established on the "grassy" shoot growth in the base of the canopy of this variety under the high humidity conditions prevalent during the sleeved period.

  31 days after de-sleeving (Table 18), leaf losses were lowest in 457 and Lilo. When expressed as a percentage leaf loss, Christmas Carol and 2969 also appeared to perform well at this stage. The highest leaf losses (sig. for P = 0.05) were still seen in Sonora (both selections) and Tabaluga Red. In general, the percentage data reinforced the straight loss-count data and did not change the interpretation of the variety performances.

- **Bract number / break and leaf loss during shelf-life:** In line with the leaf number data, Lilo had a high number of bracts per break at sleeving. Tabaluga Red and 457 also had significantly more bracts per break than the other varieties. Of the remaining varieties, Malibu had significantly fewer bracts per break (P = 0.05; Table 16).

  At de-sleeving, the highest levels of bract loss were seen in Sonora (selection a), Tabaluga Red and White Christmas, with significantly lower levels of bract loss in Xenia, Malibu or Chrismas Carol (Table 17).

  31 days after de-sleeving, bract losses were still high in Sonora (selection a) and Tabaluga Red, but also for 457. By this stage, Christmas Carol and Malibu were showing significantly reduced levels of bract loss compared to the other varieties, with Xenia, 2969, Christmas Carol and Lilo also performing better-than-average.

- **Leaf colour score:** At sleeving, Coco Red, 2969, Xenia and Lilo were all judged as having the best foliage colour, with Santa Claus, Tabaluga Red and Christmas Carol scoring below average. During shelf-life leaf scores deteriorated most markedly (calculated as the difference in score between sleeving and 31 days after de-sleeving) in 2969, White Christmas, Christmas Carol, Coco Red and Sonora (selection a) and Santa Claus.

- **Bract colour score:** At sleeving, Xenia, White Christmas, 457 and 2969 all had significantly higher bract colour scores than Santa Claus, Christmas Carol or Tabaluga Red (P = 0.05; Table 16).

  During shelf-life, White Christmas, 2969, Malibu and 457 were all judged as retaining better bract colour than the average for the other varieties, with Tabaluga, Santa Claus and Christmas Carol performing worst (Tables 17 & 18). In Table 18, a column has been inserted to identify the degree of bract colour loss in each variety (calculated as the difference between bract colour at the start and 31 days after de-sleeving). Of the varieties tested, Tabaluga had faded most, with the least colour change in Malibu, 2969 and Lilo. White Christmas actually showed the least colour difference during shelf-life, but as it is a white-bracted variety, this may be misleading.

- **Cyathia number per break:** Lilo, Tabaluga Red and Santa Claus all had significantly higher numbers of cyathia per break at the start of shelf-life than the other varieties (Table 16). Christmas Carol, Coco Red and Sonora (both selections) had fewest cyathia per break at this stage. The Cyathia in Sonora in particular, were at an early stage of development (Appendix 6, Figs. 6.3 & 6.4), with the potential for continued development during shelf-life.

  During shelf-life, Santa Claus, White Christmas and Sonora (selection a) all continued to have significantly higher numbers of cyathia per break than the majority of the other varieties. In 457, cyathia development was already advanced at the start of shelf-life, and retention during the shelf-life phase was relatively poor. In other varieties such as 2969 and Coco Red, there were relatively few cyathia were per break at the start of shelf-life, and there was little or no continued cyathia development during shelf-life (Appendix 6; Figs 6.9 & 6.10).

Table 16: New variety trail: Data at sleeving, averaged across sites ranked to give an overall impression of each variety's post-harvest performance.

		At sleeving					Ranked data					
	Variety	leaf number / break	bract Number / break	leaf Colour score	bract Colour score	Cyathia Number / break	leaf Number / break	Bract Number / break	Leaf Colour score	Bract Colour score	Cyathia Number/ break	GRAND MEAN RANK
1	Lilo	12.75	19.67	4.92	4.42	13.58	2	1	2	8	1	2.8
2	Sonora ('a')	10.67	12.75	4.58	4.33	7.92	9	11	8	9	9	9.2
3	Santa Cl	13.33	14.00	3.83	3.17	12.75	1	7	12	12	3	7
4	Wt Xmas	10.83	14.25	4.75	5.00	11.00	7	6	7	1	5	5.2
5	Sonora ('b')	10.08	13.5	4.83	4.50	8.42	11	8	5	7	8	7.8
6	Xmas Carol	11.92	13.5	3.92	3.33	6.92	4	8	11	11	12	9.2
7	Xenia	10.83	13.5	4.92	5.00	7.25	7	8	2	1	11	5.8
8	Malibu	12.00	11.83	4.83	4.75	9.17	3	12	5	5	6	6.2
9	Coco Red	9.92	15.42	5.00	4.67	7.50	12	4	1	6	10	6.6
10	2969	11.67	15.25	4.92	5.00	8.67	6	5	2	1	7	4.2
11	457	10.67	18.51	4.28	5.00	11.28	9	3	9	1	4	5.2
12	Tabaluga	11.75	19.25	4.08	4.00	13.58	5	2	10	10	1	5.6
	LSD (5%) (94 d.f)	1.02	0.26	0.27	0.33	2.49						**6.2** Mean

Variety summaries:

Lilo (Appendix 6; Fig. 6.1): High foliage and bract counts, with good leaf and bract retention during shelf-life. Leaf quality and bract colour remained good throughout shelf-life, but cyathia numbers were variable and were rapidly lost during shelf-life.

Sonora (selection 'a'; Appendix 6; Fig. 6.2): High levels of leaf and bract loss at de-sleeving and during shelf-life. Losses largely due to "grassy shoot " growth in the base of the plant which were heavily infected with *Botrytis* at de-sleeving. As Sonora produced many small subsidiary bract leaves, the loss of these reduced the overall visual appearance of the plants less than in varieties with fewer large bract leaves (e.g. Freedom). Foliage quality and bract colour scores were poorer than average by 31 d after de-sleeving. Cyathia development was maintained and numbers of cyathia remained stable throughout shelf-life.

Sonora (selection 'b'; Appendix 6; Fig. 6.3): As for selection 'a', this selection was prone to high levels of leaf and bract loss (but not as high as selection a), but the foliar quality and bract colour were retained better throughout shelf-life. Again, cyathia development and retention were fairly good.

Santa Claus (Appendix 6; Fig. 6.4): Variable, but higher than average leaf and bract losses during shelf-life. Foliage quality and bract colour were both poor and deteriorated rapidly during shelf-life. There were numerous cyathia at all stages of development which lasted well throughout shelf-life.

White Christmas (Appendix 6; Fig. 6.5): Variable amounts of leaf and bract loss, with high losses at site 3. Generally, the quality of foliage and bract colour remained good throughout shelf-life. Good cyathia performance, but cyathia were relatively undeveloped (stages 1-2) with little pollen showing.

Christmas Carol (Appendix 6; Fig. 6.6): Good leaf and bract retention, but foliage quality and bract colour were poor and deteriorated further during shelf-life. There were relatively few cyathia which tended to drop towards the end of shelf-life.

Xenia (Appendix 6; Fig. 6.7): Average leaf retention, but better-than-average bract retention. Colour scores were average, with variable numbers of Cyathia variable at developmental stages 1 – 2.

Malibu (Appendix 6; Fig. 6.8): Few bracts per break, but good bract retention during shelf-life. Leaf drop was average, but with good foliage quality and bract colour scores during shelf-life. Relatively few cyathia present with loss later in shelf-life.

Coco Red (Appendix 6; Fig. 6.9): Few leaves per break, with moderate levels of leaf and bract losses during shelf-life. Leaf and bract colour scores were below average, and colour retention was poor during shelf-life. Very poor cyathia production, with few undeveloped cyathia which were quickly lost during shelf-life.

"2969" (Appendix 6; Fig. 6.10): Consistently good bract and leaf retention, with high foliage quality and bract colour scores at the start of shelf-life. During shelf-life, bract colour remained good, but foliage scores deteriorated more than average. As with Coco Red above, few cyathia at the start of shelf-life, with little or no development and rapid cyathia loss during shelf-life.

"457" (Appendix 6; Fig. 6.11): Few leaves per break (good for packing), with very little leaf loss during shelf-life. High bract numbers per break make this variety noticeable, but it also showed high bract losses during shelf-life. Foliage quality and bract colour scores remained high throughout shelf-life. Moderate numbers of cyathia produced, but these were at advanced stages of developemt at the start of shelf-life, and were lost before the end of shelf-life.

Tabaluga (Appendix 6; Fig. 6.12): Many leaves and bracts per break, but with very high leaf and bract losses during shelf-life. Leaf quality was average, and the pale bracts faded rapidly during shelf-life. Cyathia development was balanced (stages 1 through to 5), but performance was variable.

Overall : New varieties

- For a variety to perform well, it should produce plants with consistently lower than average loss / deterioration rates across ALL sites i.e. to produce a high quality product when grown under a wide range of cultural conditions.

- The plant should be balanced i.e. with good leaf and bract retention, high leaf quality and bract colour scores, and with cyathia present at various stages of development throughout shelf-life.

- Of the above varieties, despite not excelling in any particular area, Xenia performed consistently well and achieved a good average score. Lilo, Malbu, 2969, White Christmas and Sonora (selection b) all performed better than average. Overall, Tabaluga Red performed consistently below average.

- The performance of Sonora was variable between the two selections tested, and factors that led to these differences cannot be determined from the data currently available.

Table 17: New variety trial: Data at de- sleeving, averaged across sites ranked to give an overall impression of each variety's post-harvest performance.

		At de-sleeving									Ranked data								
	Variety	Leaf loss (srt)	Leaf loss (mean)	Leaf loss (%)	Bract loss (srt)	Bract loss (mean)	Bract loss (%)	Leaf colour score	Bract colour score	Cyathia number / break	Leaf loss	Leaf loss (%)	Bract loss	Bract loss (%)	Foliar colour score	Bract colour score	Cyathia number / break	GRAND MEAN RANK 1	GRAND MEAN RANK 2
1	Lilo	2.16	4.306	5.29	1.306	1.332	1.90	4.917	4.417	8.75	6	4	6	5	2	5	8	5.4	4.8
2	Sonora ('a')	3.76	13.765	15.54	1.717	2.574	5.63	4.583	3.917	8.92	12	11	12	12	8	9	7	9.6	9.4
3	Santa Cl	2.34	5.102	5.56	0.954	0.535	0.80	3.833	2.917	16.58	7	6	4	3	12	12	1	7.2	6.8
4	Wt Xmas	2.70	6.921	9.40	1.549	2.023	3.21	4.667	4.833	12	9	9	10	8	6	2	3	6	5.6
5	Sonora ('b')	3.66	13.068	17.69	1.129	0.901	2.09	4.833	4.083	9.33	11	12	5	6	5	8	5	6.8	7.2
6	Xmas Carol	1.575	2.106	2.75	0.83	0.314	0.92	3.917	3.000	6.58	1	1	3	4	11	11	10	7.2	7.4
7	Xenia	2.392	5.346	7.07	0.752	0.191	0.47	4.917	4.250	9.08	8	8	1	1	2	7	6	4.8	4.8
8	Malibu	1.819	2.933	3.62	0.782	0.237	0.47	4.917	4.750	8.58	2	2	2	1	2	3	9	3.6	3.4
9	Coco Red	2.153	4.261	6.63	1.428	1.666	4.49	5	4.333	4.92	5	7	8	11	1	6	12	6.4	7.4
10	2969	1.924	3.328	4.53	1.386	1.545	3.41	4.583	4.583	6.58	4	3	7	9	8	4	10	6.6	6.8
11	457	1.875	3.14	5.35	1.586	2.141	3.85	4.598	4.939	11.56	3	5	11	10	7	1	4	5.2	5.4
12	Tabaluga	3.459	11.591	13.46	1.486	1.786	2.34	4.083	3.250	13.67	10	10	9	7	10	10	2	8.2	7.8
	LSD (5%) (94 d.f.)	0.78			0.64			0.351	0.29	2.884							Mean	**6.4**	**6.4**

Table 18: New variety trial: Data 31 days after de-sleeving, averaged across sites and ranked to give an overall impression of each varieties post-harvest performance.

		31 d after de-sleeving										Ranked data								
	Variety	Leaf loss (srt)	Leaf loss (mean)	Leaf loss (%)	Bract loss (srt)	Bract loss (mean)	Bract loss (%)	Leaf colour score	Bract colour score	Bract colour loss	Cyathia number / break	Leaf loss	Leaf loss (%)	Bract loss	Bract loss (%)	Foliar colour score	Bract colour score	Cyathia number / break	GRAND MEAN RANK 1	GRAND MEAN RANK 2
1	Lilo	4.216	17.40	21.39	2.63	6.56	9.33	4.33	3.13	1.29	0.42	2	1	5	3	3	7	8	5	4.4
2	Sonora ('a')	6.398	40.56	45.80	3.68	13.18	28.82	3.67	3.00	1.33	2.25	12	12	11	12	10	8	3	8.8	9
3	Santa Cl	5.276	27.46	29.94	3.07	9.05	13.52	3.13	1.75	1.42	6.29	8	5	8	6	11	11	1	7.8	6.8
4	Wt Xmas	5.580	30.76	41.77	3.05	8.93	14.18	3.75	4.08	0.92	3.50	10	10	6	8	9	1	2	5.6	6
5	Sonora ('b')	5.468	29.53	39.97	3.06	9.00	20.86	4.46	3.25	1.25	0.83	9	9	7	9	1	5	7	5.8	6.2
6	Xmas Carol	4.277	17.92	23.38	1.56	2.07	6.07	3.00	1.83	1.50	1.25	4	2	1	2	12	10	5	6.4	6.2
7	Xenia	5.045	25.07	33.16	2.34	5.08	12.57	4.08	3.25	1.75	1.67	6	7	3	5	5	5	4	4.6	5.2
8	Malibu	5.127	25.91	31.99	1.69	2.47	4.94	4.25	3.5	1.25	0.33	7	6	2	1	4	3	9	5	4.6
9	Coco Red	4.960	24.23	37.69	3.32	10.63	28.63	4.08	2.92	1.75	0.00	5	8	9	11	5	9	11	7.8	8.8
10	2969	4.232	17.54	23.86	2.41	5.46	12.05	3.92	3.75	1.25	0.00	3	3	4	4	7	2	11	5.4	5.4
11	457	3.946	15.20	25.90	3.70	13.35	24.03	4.39	3.46	1.54	0.25	1	4	12	10	2	4	10	5.8	6
12	Tabaluga	6.146	37.40	43.42	3.33	10.74	14.06	3.88	1.75	2.25	1.08	11	11	10	7	8	11	6	9.2	8.6
	LSD (5%) (89 d.f.)	0.940			1.032			0.356	0.299		1.738							Mean	**6.4**	**6.4**

3.3 Propoxur smoke trial

The small scale of the trial, with few plants of many varieties made statistical analysis difficult and therefore data were summarised and means and standard deviations of the means calculated for each variable. Graphs have been plotted to show changes in each variable with time after treatment compared to control plants (See Appendix 7).

The data indicate that under the conditions described for the trial, the combination of propoxur smoke and Applaud, applied at the recommended rates, had no visible deleterious effects on plants when applied to crops in full colour. The observed changes in cyathia development and bract colouration with time were no more than could be expected from naturally ageing plants over the same period. The only variety where evidence of bract edge damage was noticed was Highlight White, and in this instance damage was minimal.

Generally, there were no consistent trends in the data that suggest the treated plants deteriorated any quicker than the untreated controls.

It must be emphasised, that although there were no obvious marked signs of phytotoxicity observed under the conditions as described in the current trial, care must be taken to avoid inappropriate timing or use of propoxur smoke, in terms of application rate, plant condition, plant water status, and prevailing environmental conditions, for potential risks of plant damage to be minimised.

4. CONCLUSIONS

Effects of cool-growing at the end of production on plant quality at marketing:

- Reduced production delays, combined with enhanced quality of bract and foliage, and cyathia longevity, may make late-season cool-growing a more attractive approach for maintaining quality at this time of year than extended season cool-growing techniques.

- Finishing pots at 15°C from week 43 delayed the crop by an average of 7– 10 days (and longer in low light). Although this delay was far less severe than in crops produced with whole-season cool-growing (see 1995-96 trials), cool-finished crops should be potted at least a week earlier than crops under standard temperature regimes to avoid a delay in marketing.

- Cool-growing can be used to advantage in varieties which produce larger faded bracts when grown using conventional temperature regimes. Cool growing post-initiation generally increased foliage and bract colour and quality, whilst reducing bract size. In Freedom, this may be desirable, but Spotlight produced rather small bracts when grown at cooler temperatures. This could be partially offset by increasing temperatures late in the season (week 46). Sonora and Lilo produced consistently high quality plants over the range of treatments imposed, but the combination of warm temperatures and shading late in production still markedly reduced quality even in these varieties.

- Cyathia number and stage of development were strongly affected both by temperature and light, with cool-growing delaying cyathia development at the standard marketing stage (relative to bract colouration). This resulted in cool-grown plants having more intact cyathia at harvest than in comparable plants finished at 21°C, with the potential benefits of continued cyathia development during shelf-life. Low light levels during production restricted the number of cyathia reaching maturity, with many immature buds being aborted and dropped before marketing.

Effects of market stage on post-harvest performance

Definition of optimal market stage: It is not possible to generalise and define a precise physiological stage for marketing in all varieties because cyathia development occurs at different rates in relation to bract colour as temperature changes. The rates of cyathia development relative to bract colour development are also variety specific. It is possible to illustrate how bract colour, bract size and cyathia development all change with temperature and market stage, so that for varieties with particular characteristics, the optimal marketing stage can be defined.

- High temperatures towards the end of the crop promoted more rapid cyathia development relative to bract colouration resulting in plants with over-developed cyathia at marketing. This was predominant in Lilo and Freedom in which cyathia development was quicker than in Spotlight and Sonora.

- Cool temperatures at the end of production slowed cyathia development relative to bract colouration and resulted in plants with cyathia which had longer post-harvest potential, giving the consumer an intact plant for longer than would be possible from plants finished warmer.

    - In varieties with rapid cyathia development e.g. Lilo, market early and use cool-finishing to check cyathia development for a more "complete" plant at marketing.

    - In varieties where cyathia development is very slow e.g. Spotlight, you can afford to manipulate temperature both up and down later in the season with relatively little impact on cyathia development.

    - In all cases plants should be marketed early in order to retain plant quality and "completeness" (i.e. with cyathia intact) for longer post-harvest.

- Cool-finished plants retained better bract colour during shelf-life when marketed late than plants finished at 21°C.

- Finishing the crop cool had no deleterious effects on post-harvest performance in pots marketed early. However, if marketing were to be delayed by 7-10 days, there was evidence that plants held-cool may suffer from increased leaf and bract losses later on during post-harvest (when compared to warm-finished plants). The grower needs to trade-off the improvement in bract colour at marketing with potential for poor bract life (beyond 4 weeks) if marketing is delayed by more than a week. Although later marketing of plants finished at higher temperature resulted in better post-harvest bract life, this must be offset against the negative factors such as enlarged and faded bracts that develop under these conditions.

New varieties produced under commercial conditions

- When produced in a range of commercial environments, Xenia, Malibu, Lilo and 2969 all performed consistently well during shelf-life.

- Under the conditions of this trial, Tabaluga, Coco Red, and Santa Claus all tended to show higher than average leaf and bract losses, with more rapid bract fading than the other varieties tested.

- Performance of Sonora was variable between the two selections tested and factors that led to these differences cannot be determined from the current data.

Propoxur smoke and Applaud for late-season control of white-fly infestation

- A late season application of propoxur smoke followed by Applaud was safely used over a range of Pointsettia varieties in advanced bract colour. However, application of these pesticides must be carried out according to the specific recommendations of the chemical manufacturer. The plants must be well-watered and not under stress at the time of treatment, to reduce risk of damage. This application does not have label approval for Poinsettias and must therefore be used at 'growers risk'.

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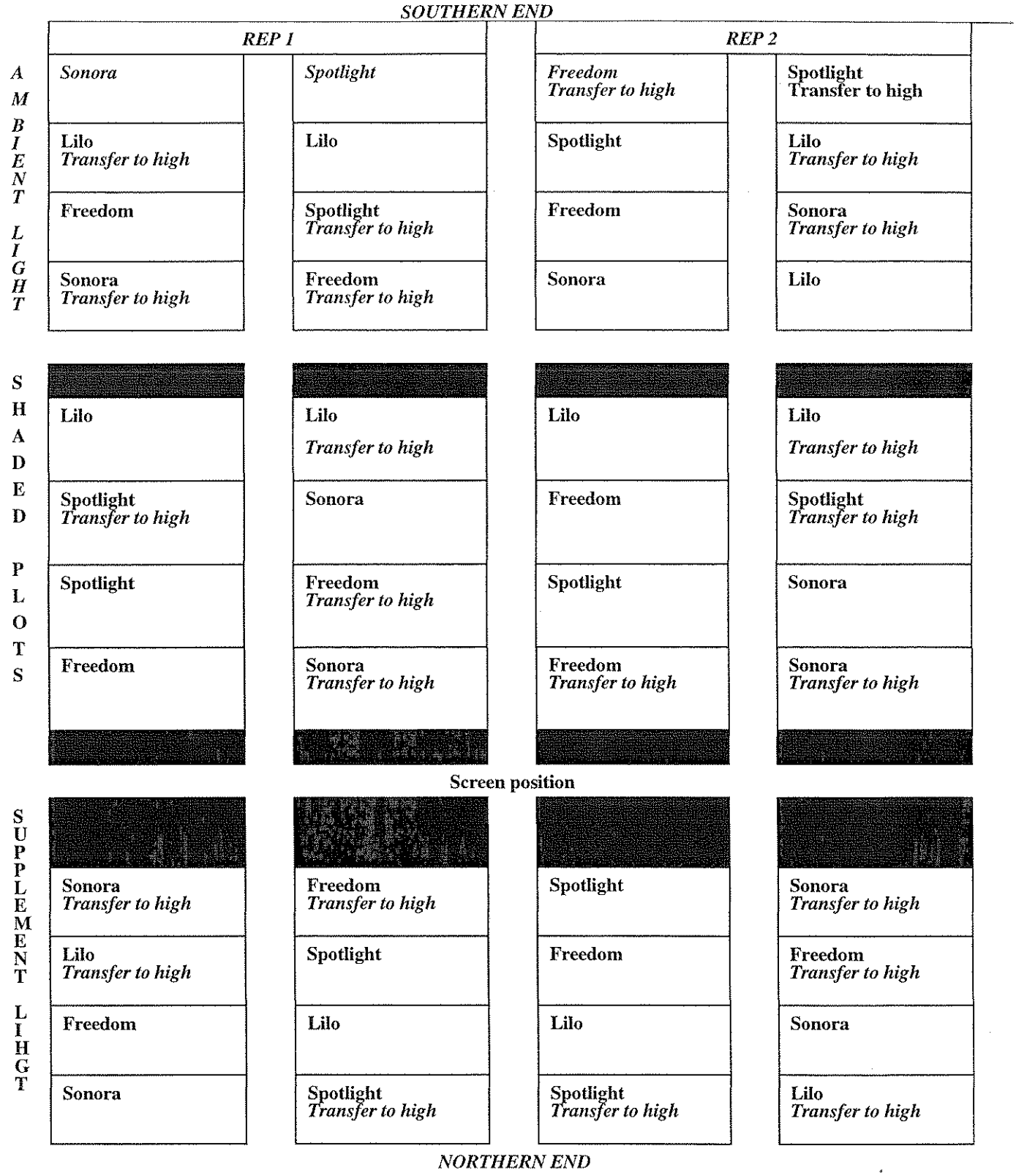
APPENDIX 1 :
Compartment layouts

Appendix 1a : Poinsettia trial layout : Q1, 15°C



Appendix 1b : Poinsettia trial layout : Q2, 21°C

SOUTHERN END

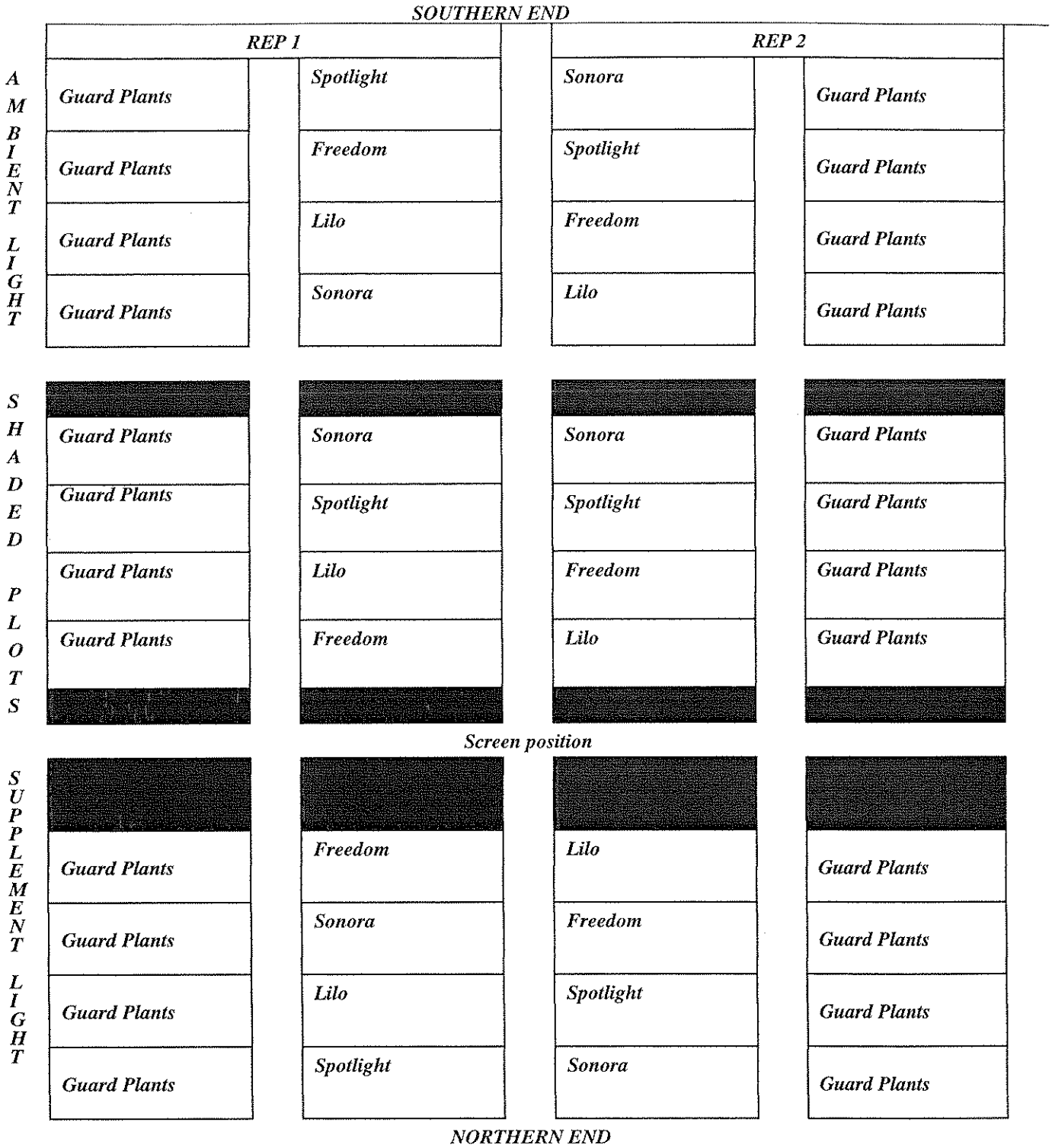
	REP 1		*REP 2*	
AMBIENT LIGHT	*Spotlight* *Transfer to low*	*Freedom*	*Spotlight*	*Sonora*
	Freedom *Transfer to low*	Lilo	Lilo *Transfer to low*	Freedom *Transfer to low*
	Sonora *Transfer to low*	Spotlight	Freedom	Sonora *Transfer to low*
	Lilo *Transfer to low*	Sonora	Lilo	Spotlight *Transfer to low*
SHADED PLOTS	Lilo	Sonora	Lilo *Transfer to low*	Spotlight
	Spotlight	Lilo *Transfer to low*	Sonora	Freedom
	Spotlight *Transfer to low*	Freedom *Transfer to low*	Lilo	Sonora *Transfer to low*
	Sonora *Transfer to low*	Freedom	Freedom *Transfer to low*	Spotlight *Transfer to low*

Screen position

SUPPLEMENT LIGHT	Spotlight	Freedom	Freedom *Transfer to low*	Spotlight *Transfer to low*
	Lilo *Transfer to low*	Spotlight *Transfer to low*	Sonora	Lilo
	Sonora *Transfer to low*	Lilo	Spotlight	Lilo *Transfer to low*
	Freedom *Transfer to low*	Sonora	Freedom	Sonora *Transfer to low*

NORTHERN END

Appendix 1c : Poinsettia trial layout : Q3, 18°C



Appendix 1d: Single plot layout

From final spacing – market . In plots where plants sampled at the "early" market stage were removed to shelf-life, the pots labelled G1,2 and 3 were moved in to guard the remaining 9 recorded pots (labelled 1-12).

G1X	X	X	X	X	
1X	2X	3X	4X	X	
G2X	5X	6X	7X	8X	
9X	10X	11X	12X	X	
G3X	X	X	X	X	

APPENDIX 2 : Climate graphs

Appendix 2

Figure 1 External Temperatures at HRI Efford 1997

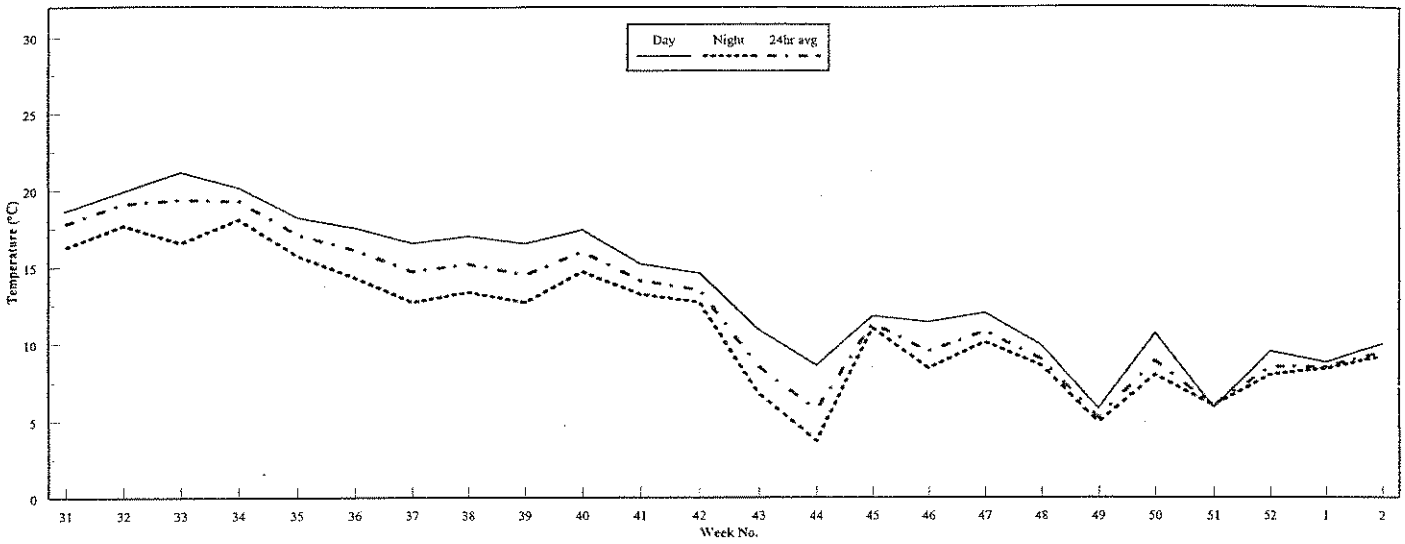
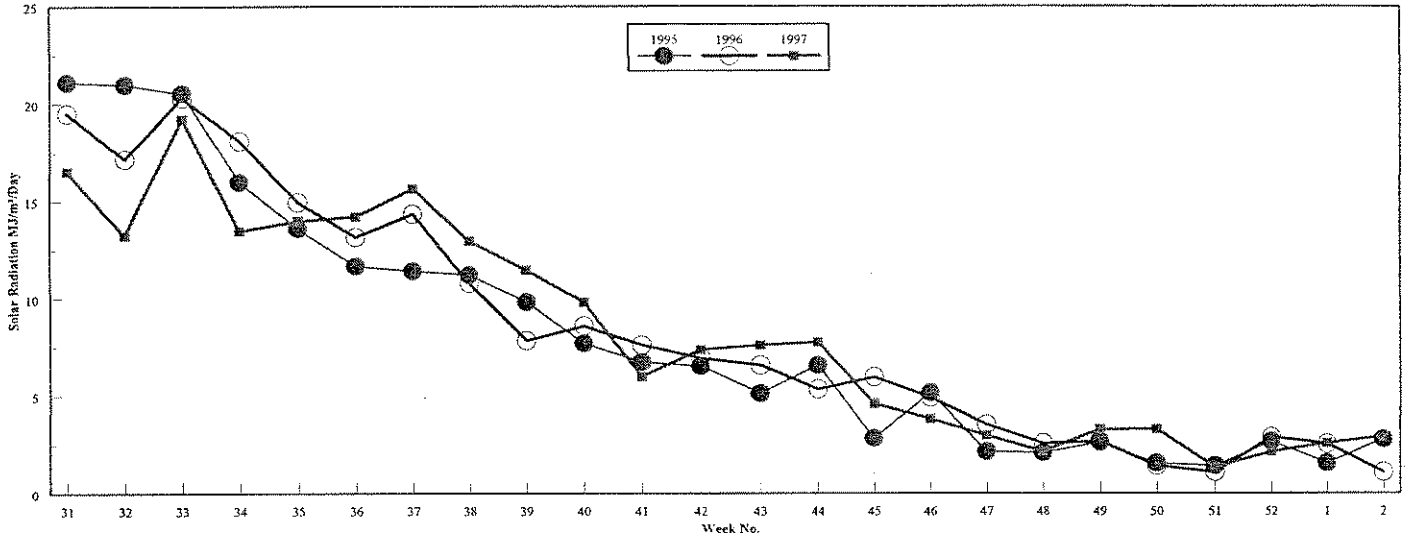


Figure 2 External Solar Radiation at HRI Efford 1995-1997



Appendix 2

Figure 3

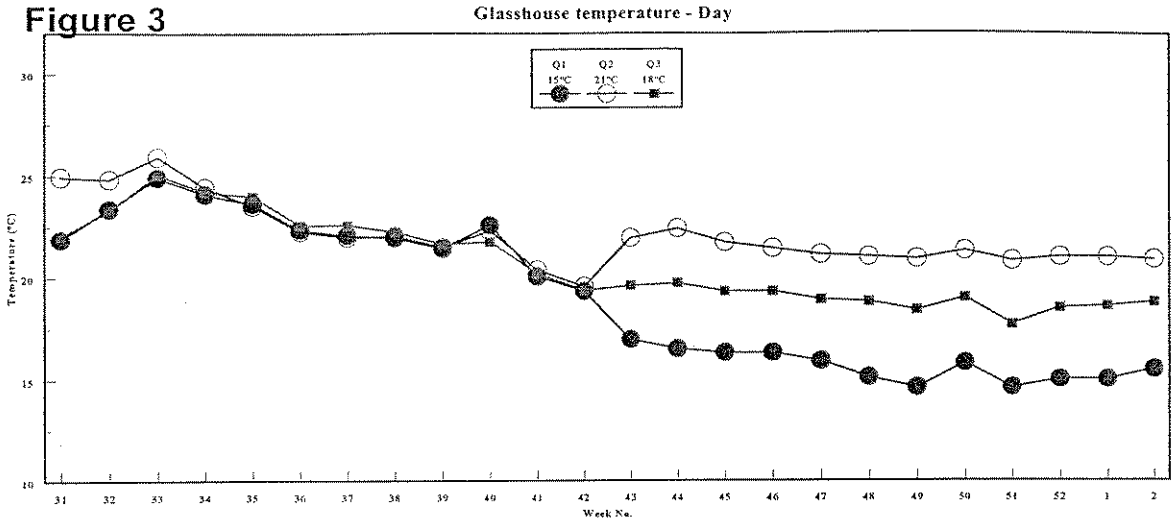


Figure 4

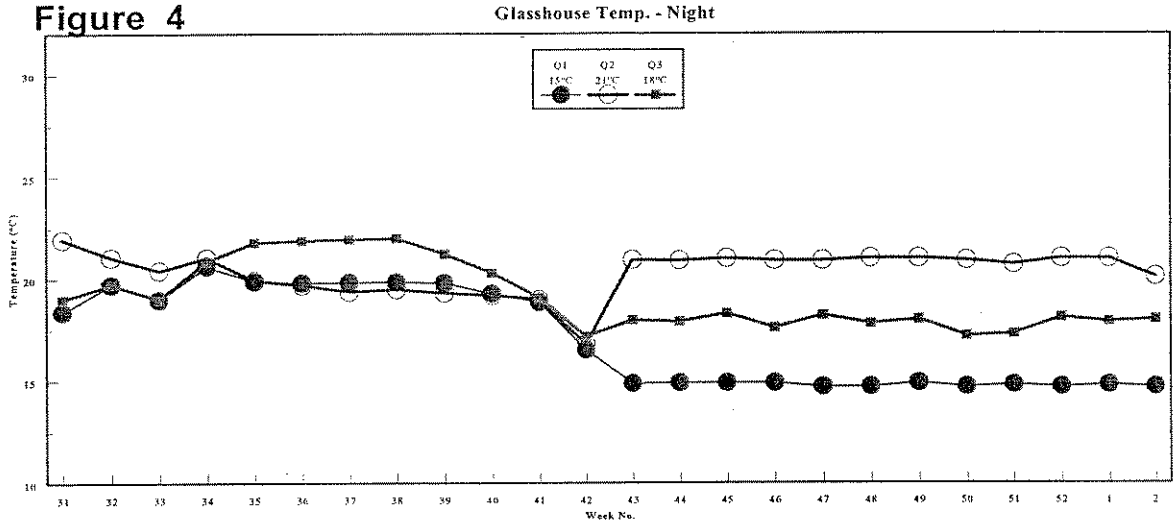


Figure 5

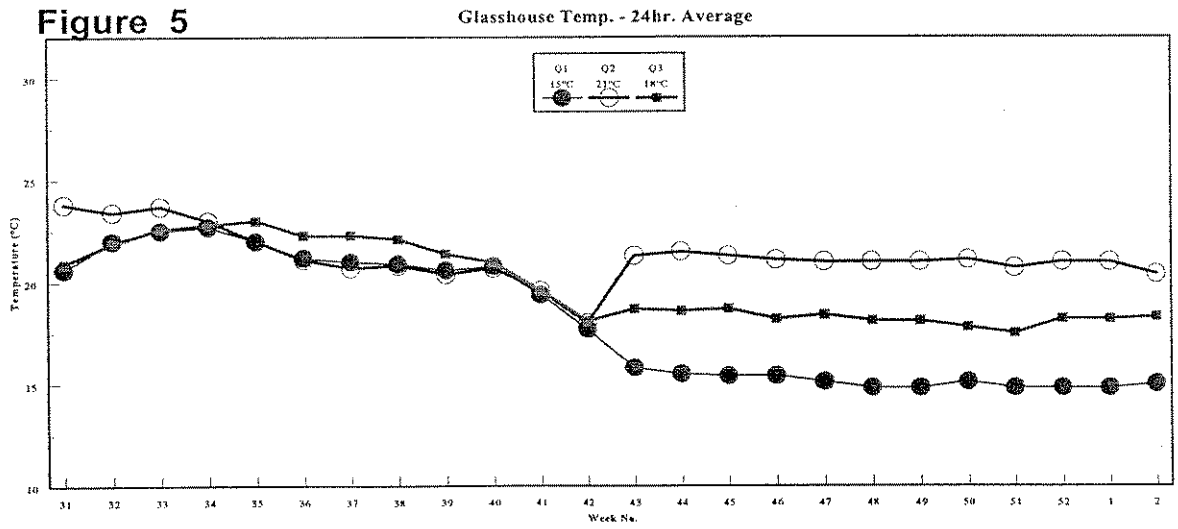


Figure 6

Relative Humidity - Day

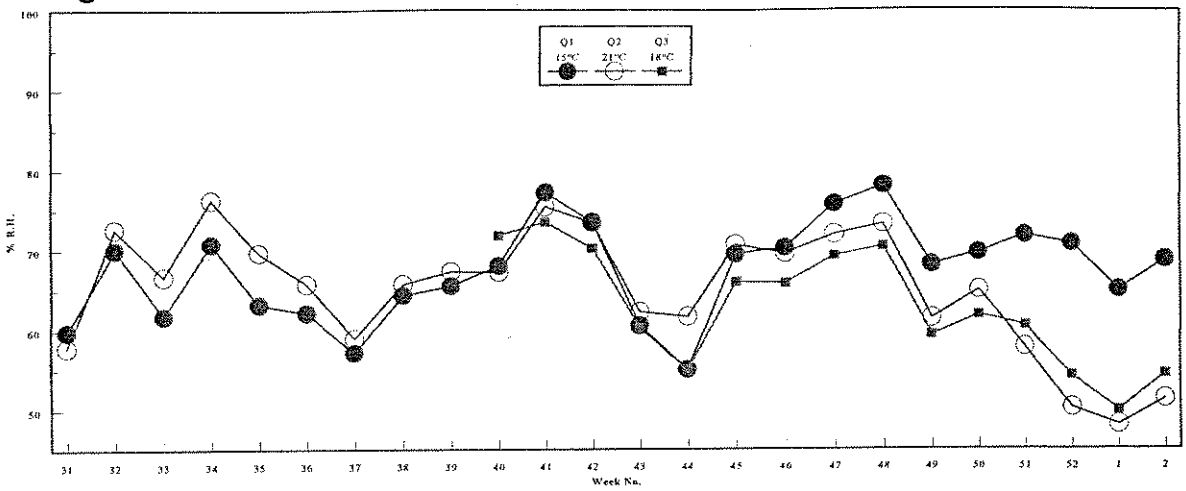


Figure 7

Relative Humidity - Night

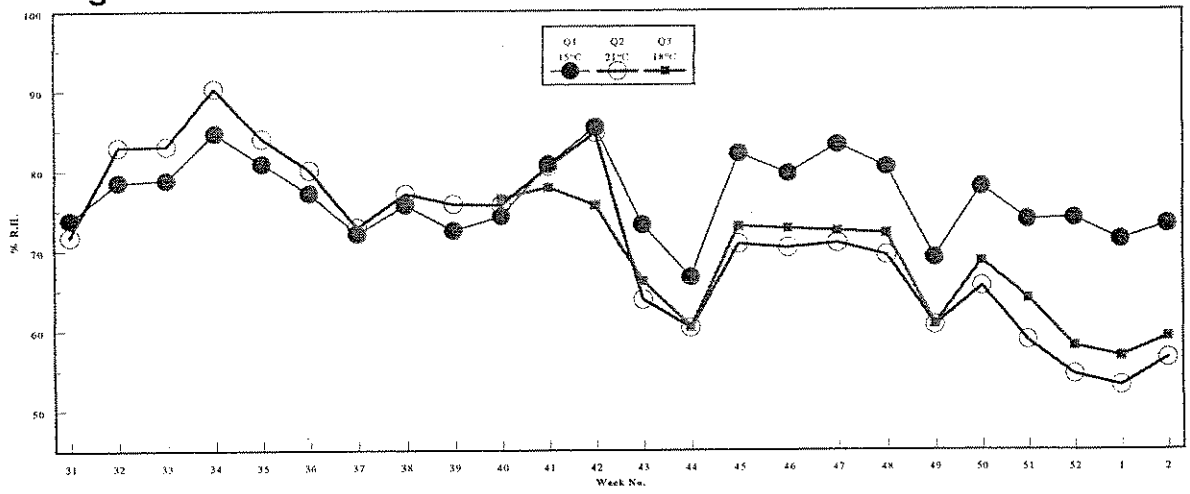
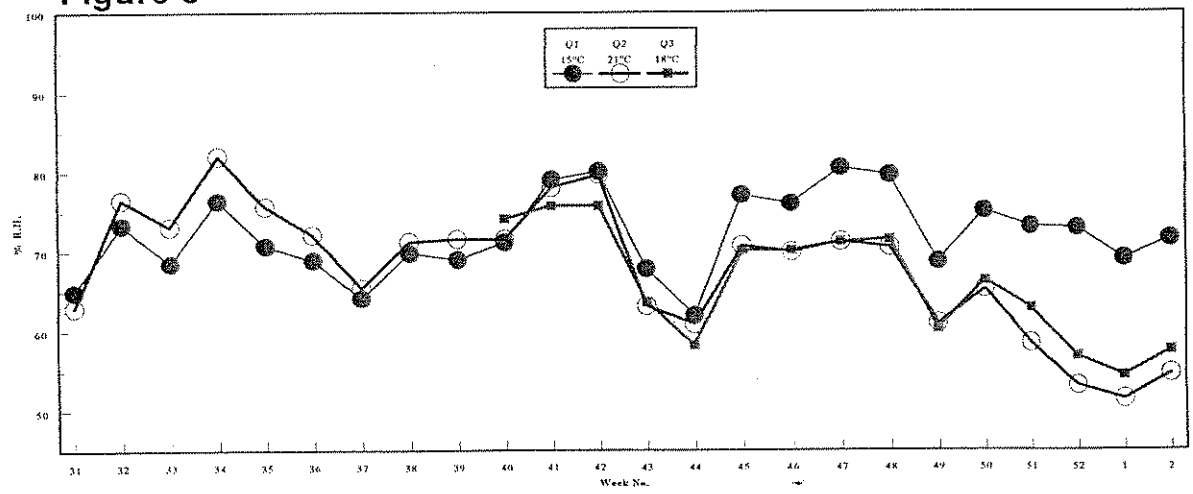


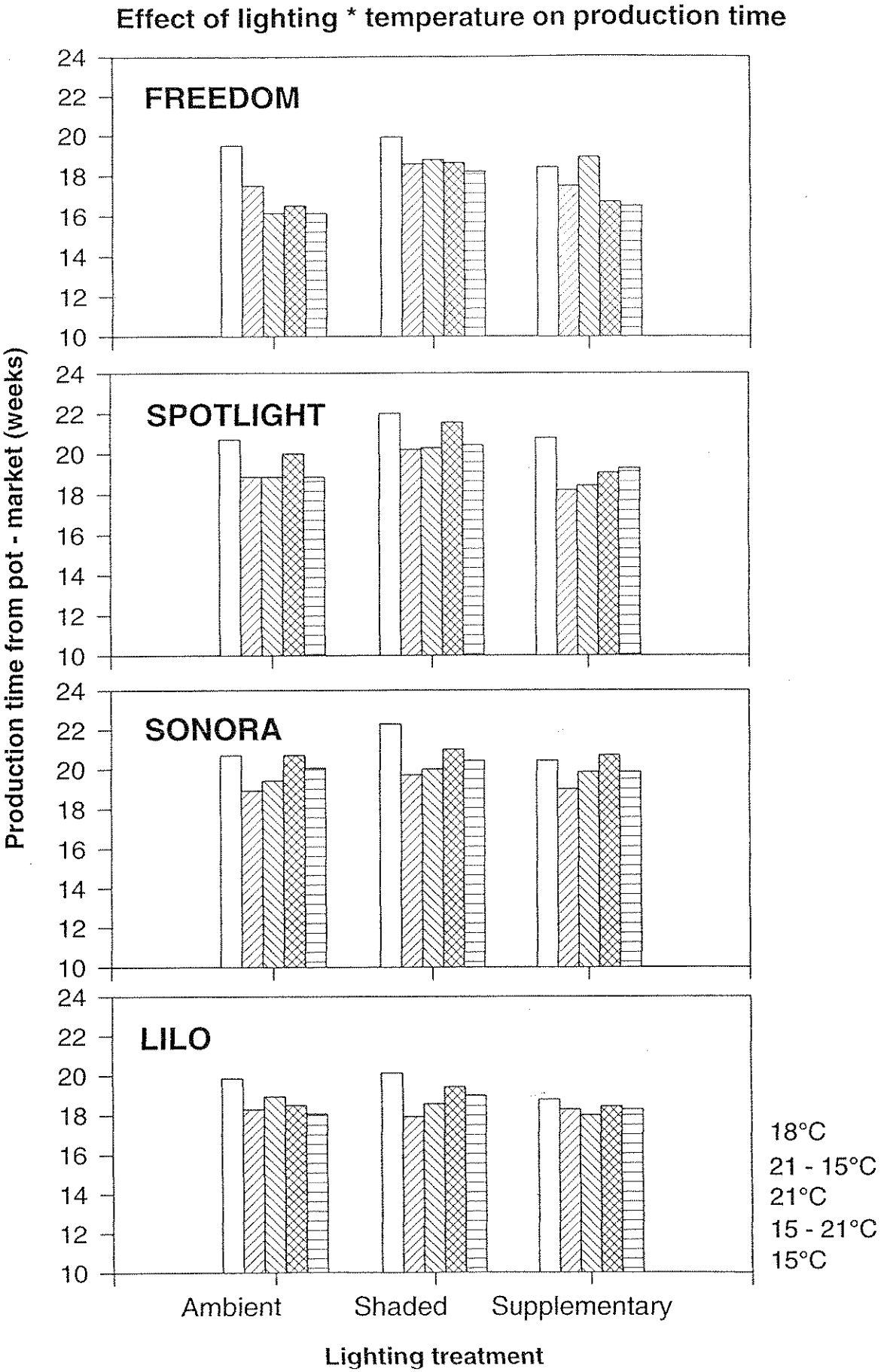
Figure 8

Relative Humidity - 24hr. Average

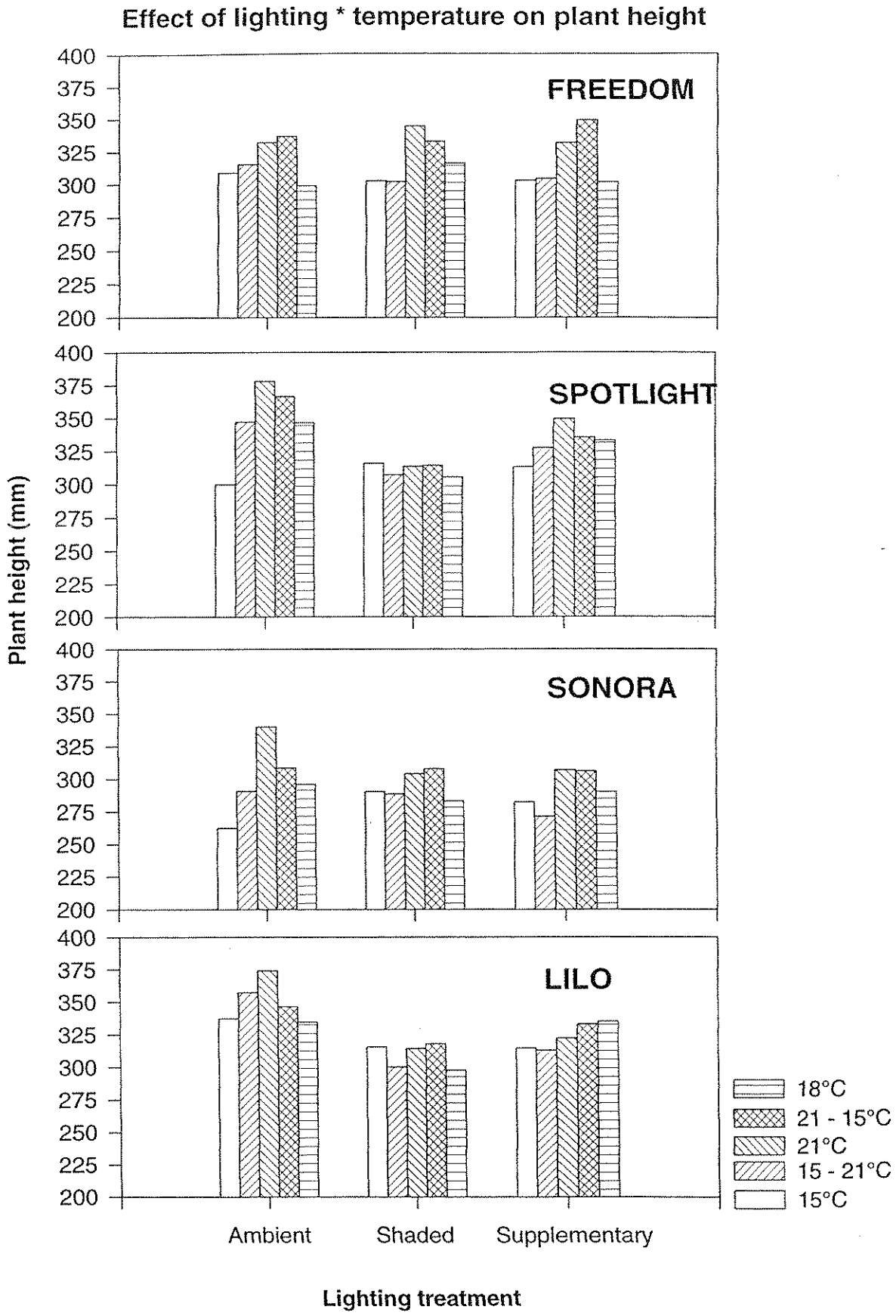


APPENDIX 3 : Marketing records: Efford trial

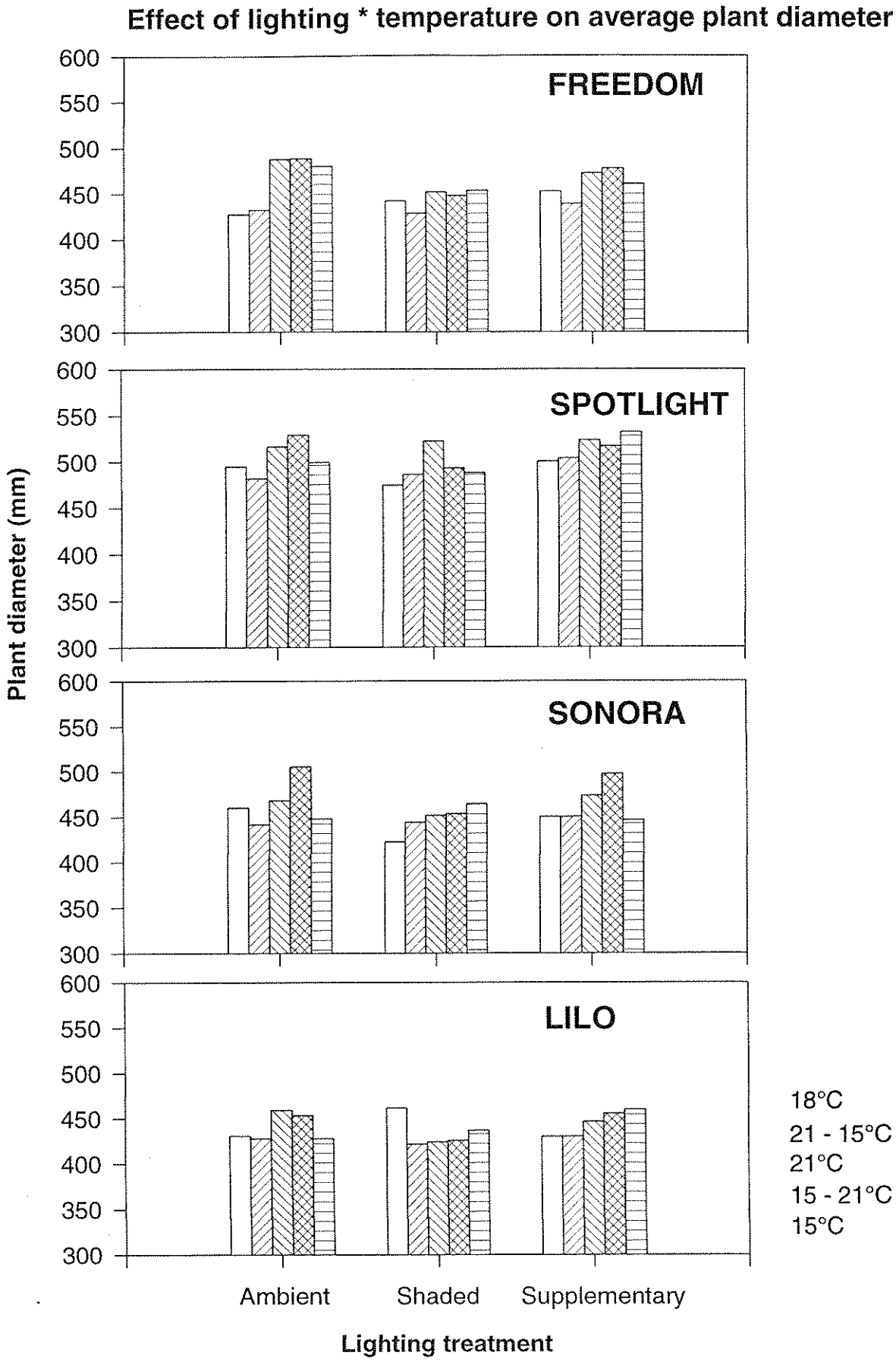
Appendix 3: Figure 1



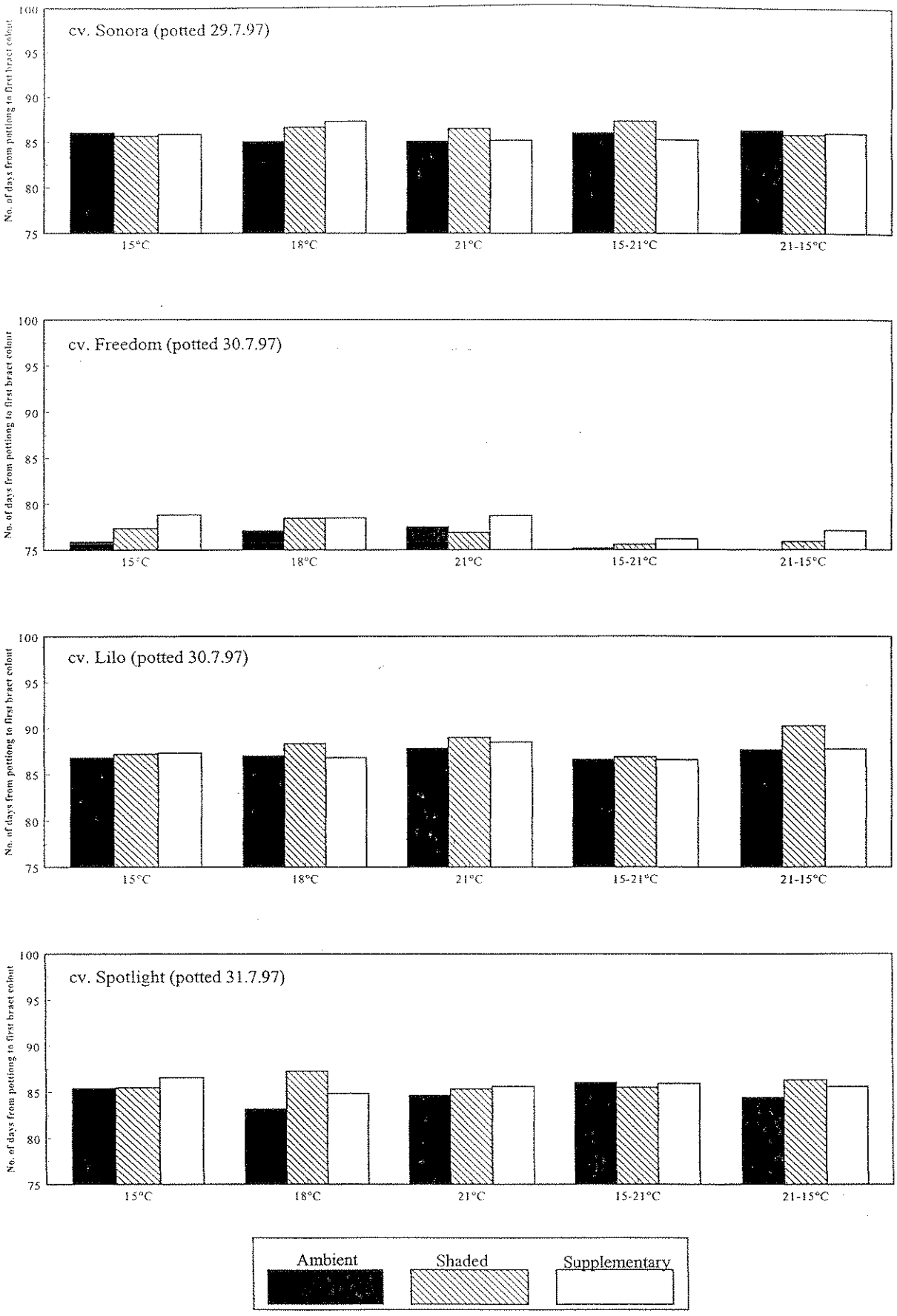
Appendix 3: Figure 2



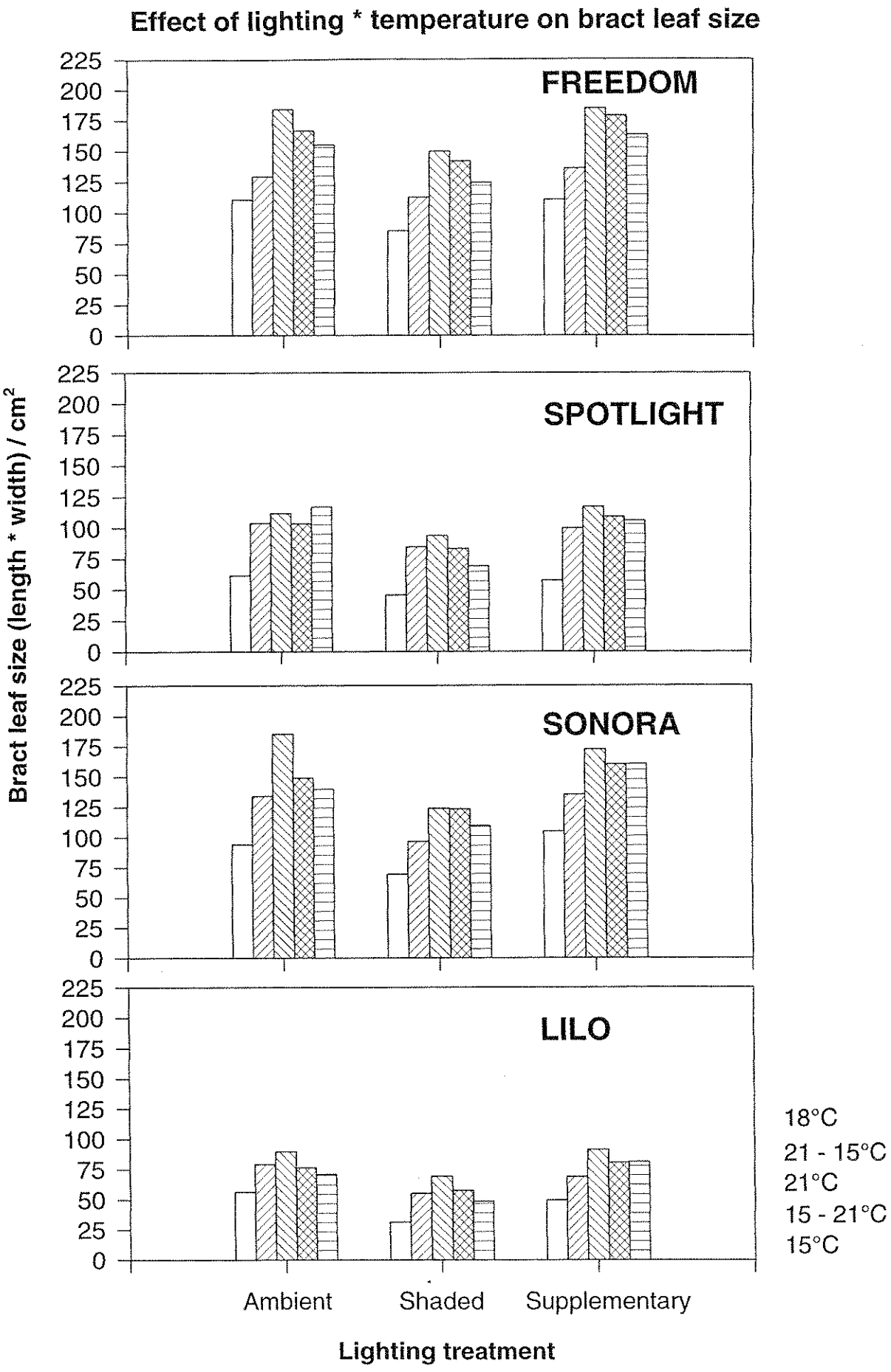
Appendix 3: Figure 3

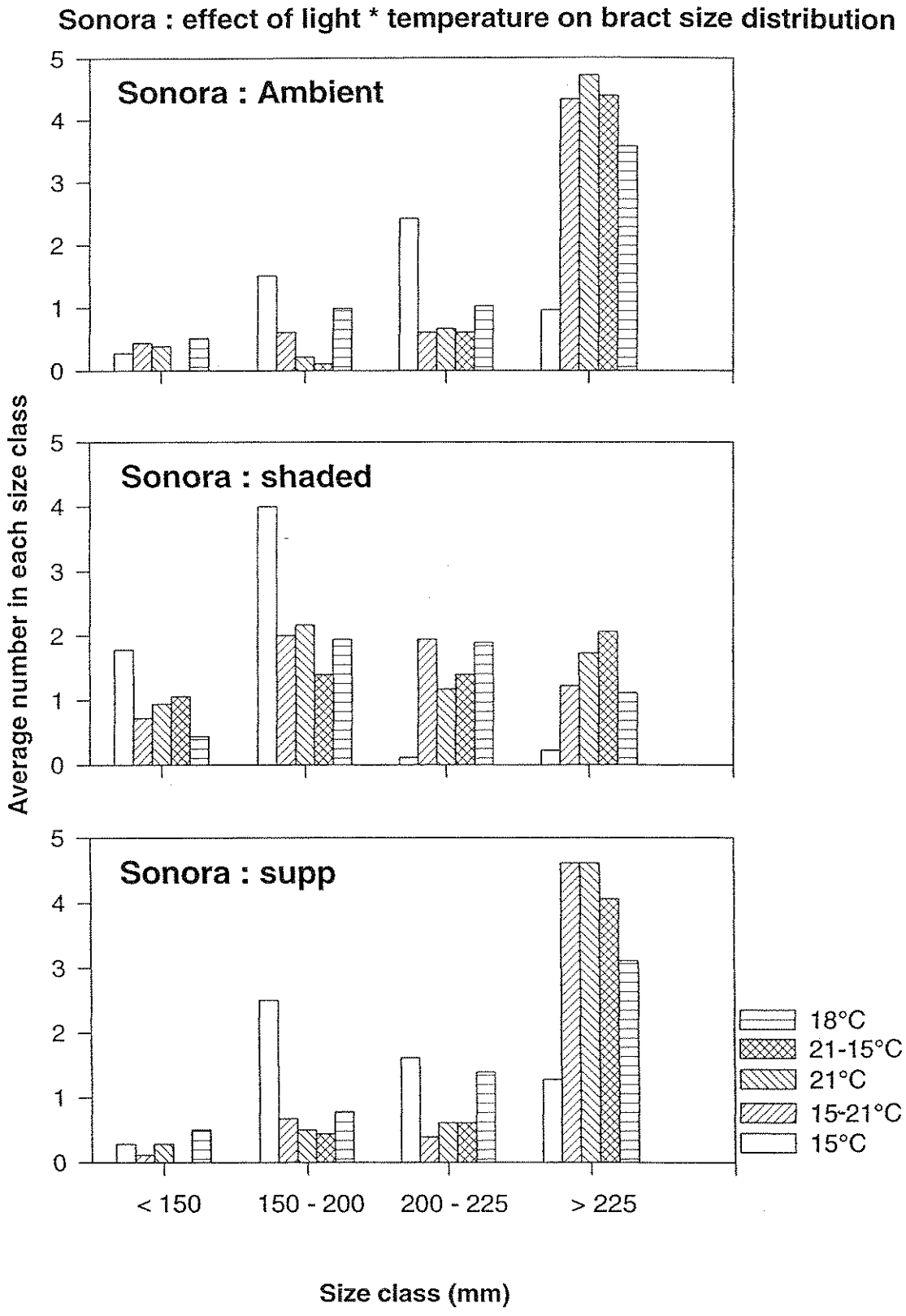


Appendix 3: Figure 4

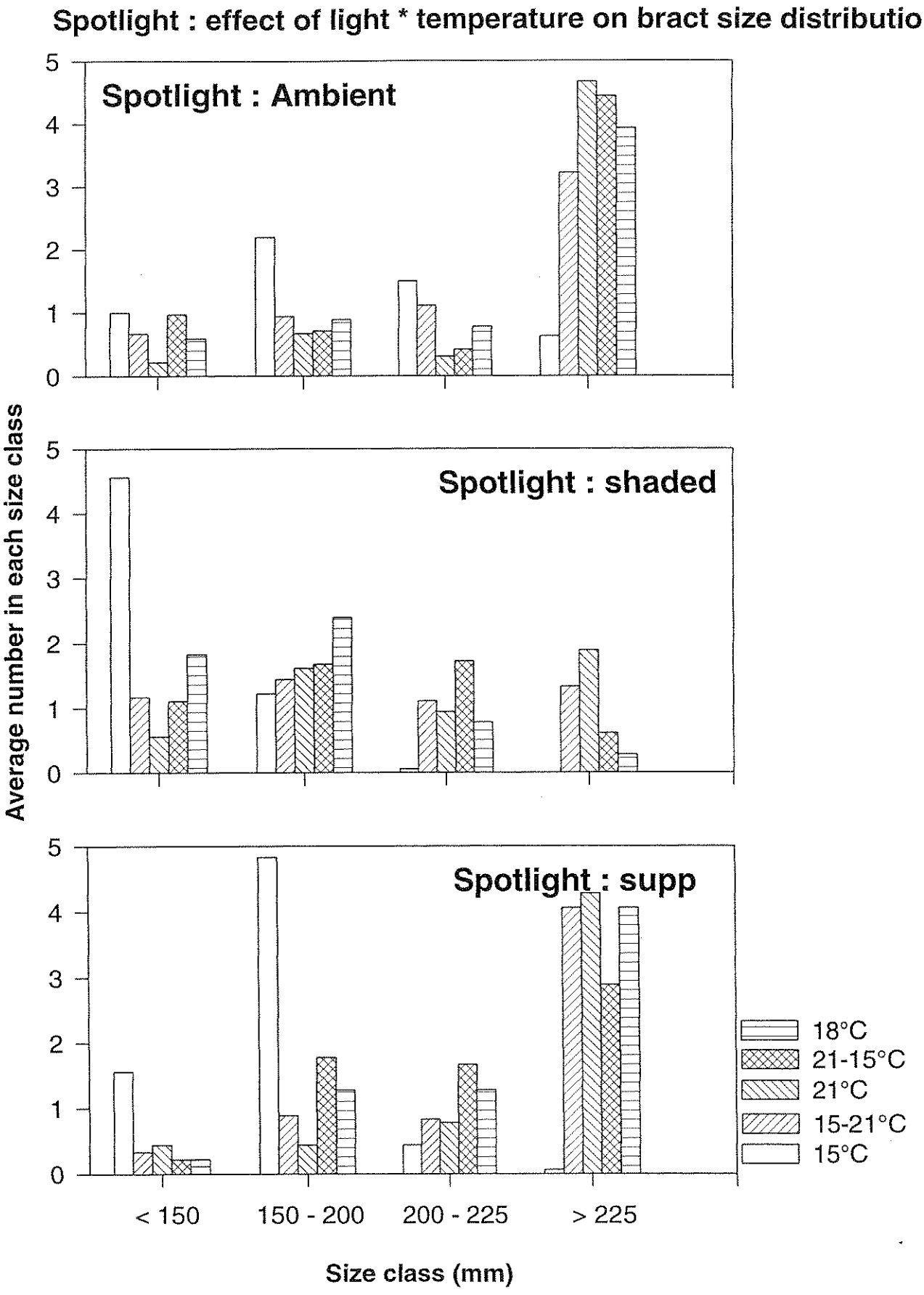


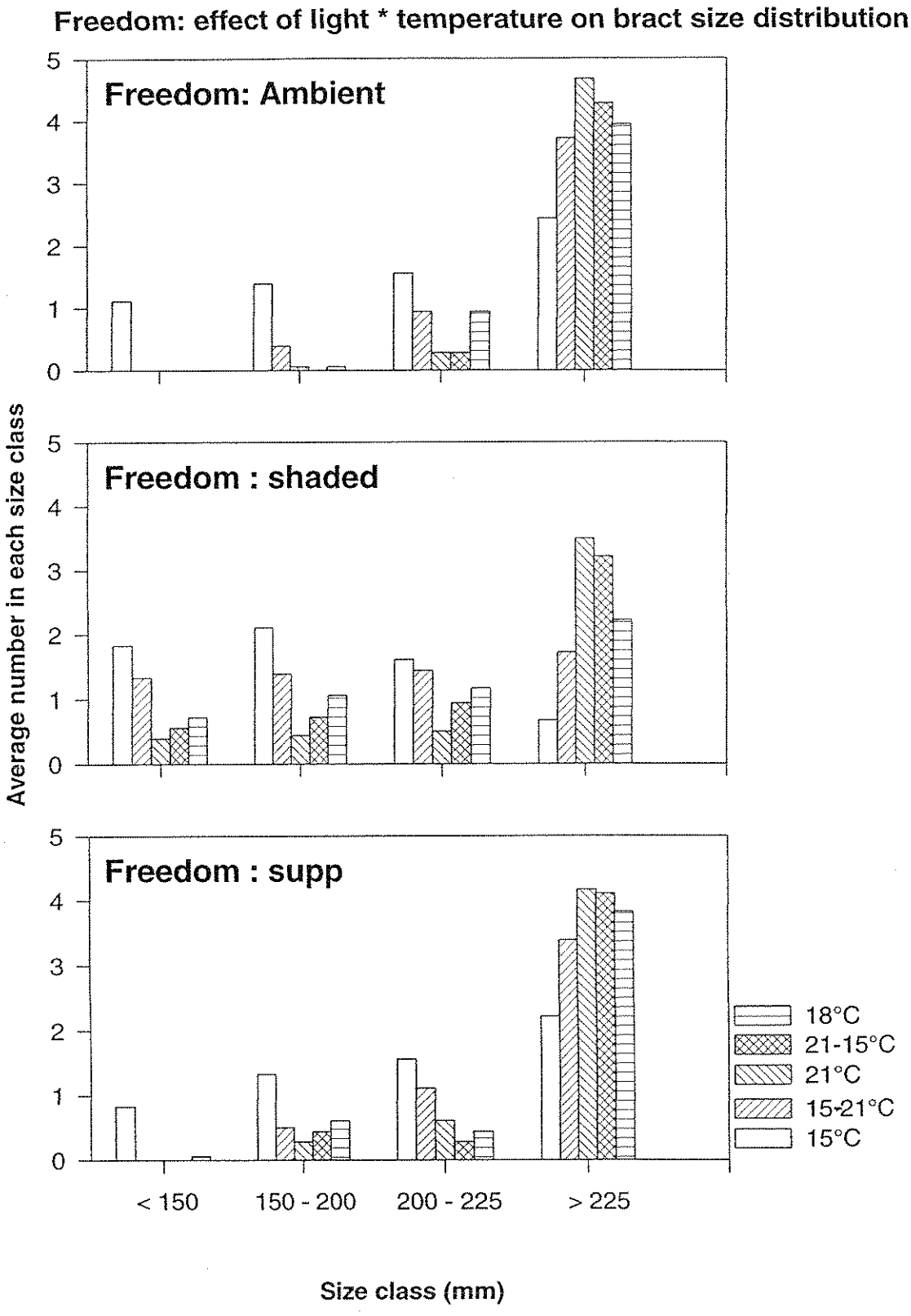
Appendix 3: Figure 5

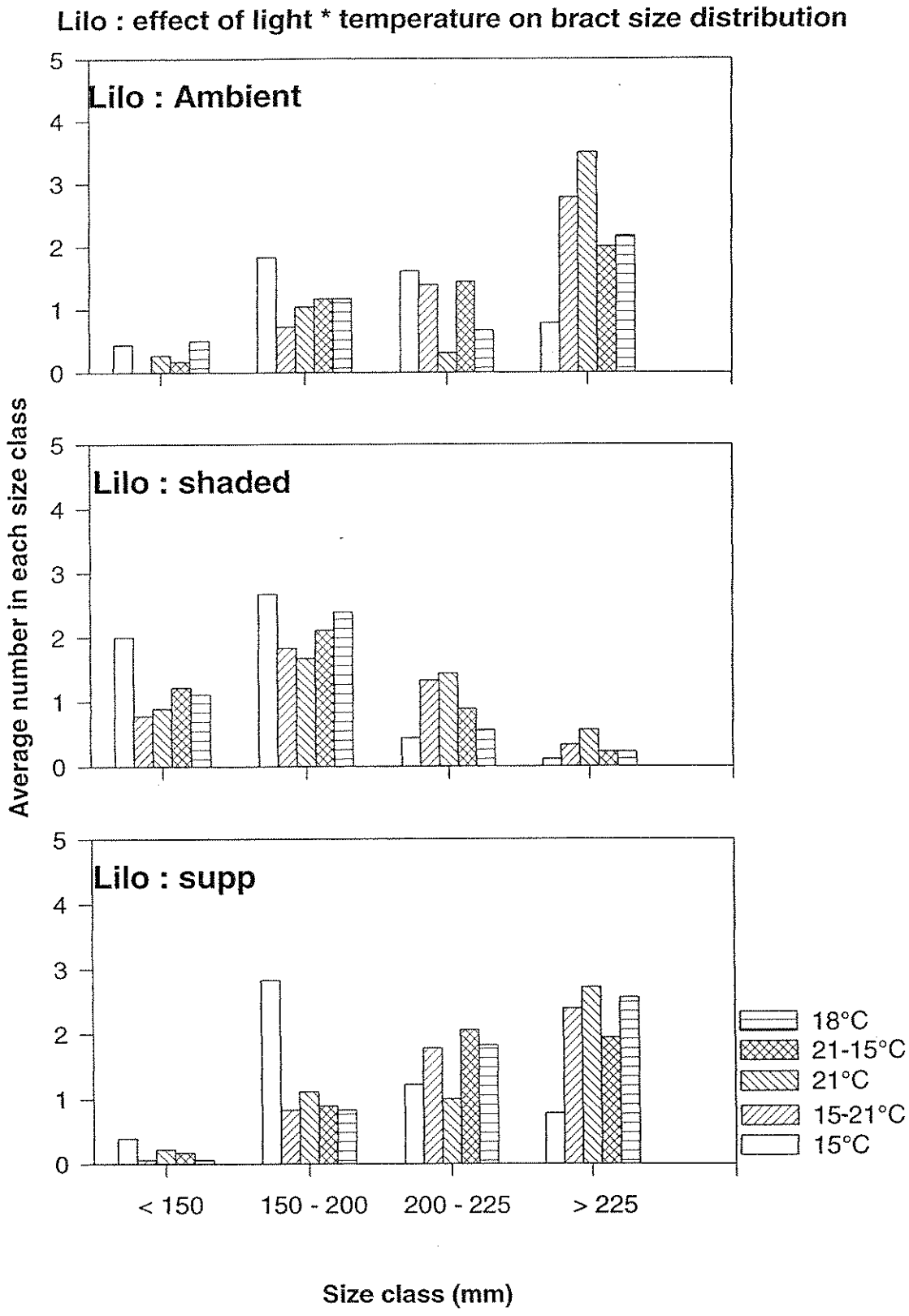


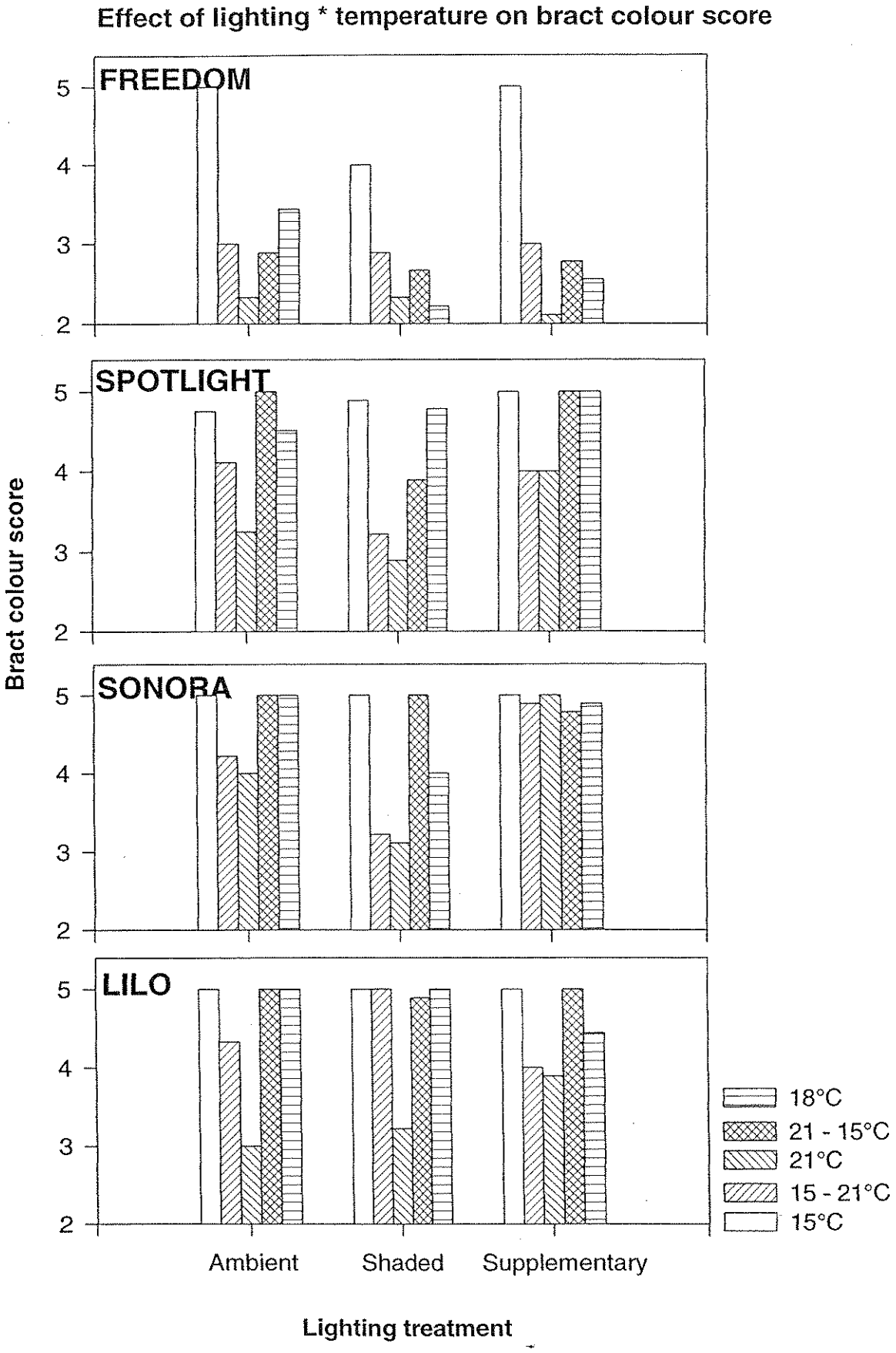


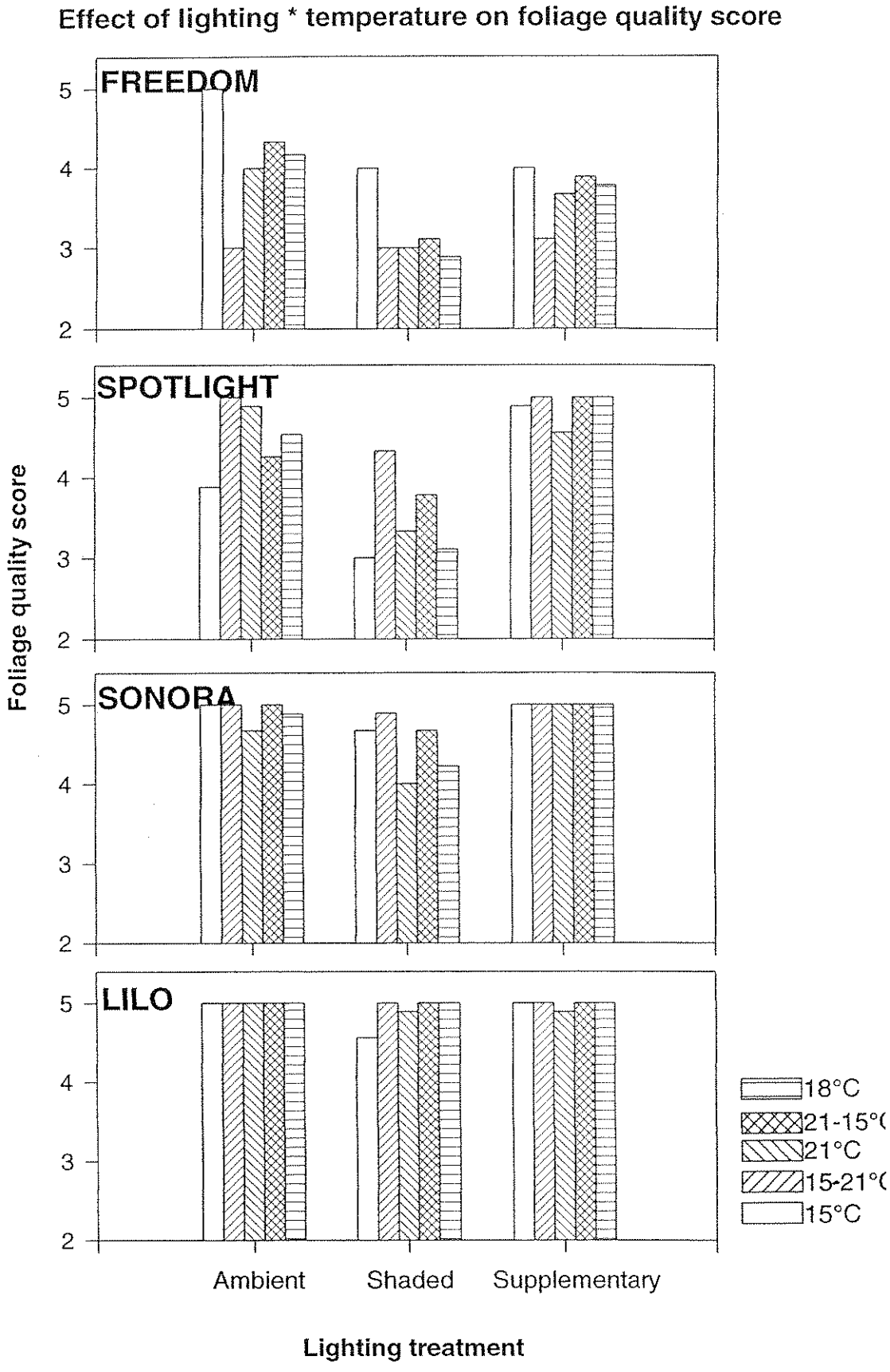
Appendix 3: Figure 6b

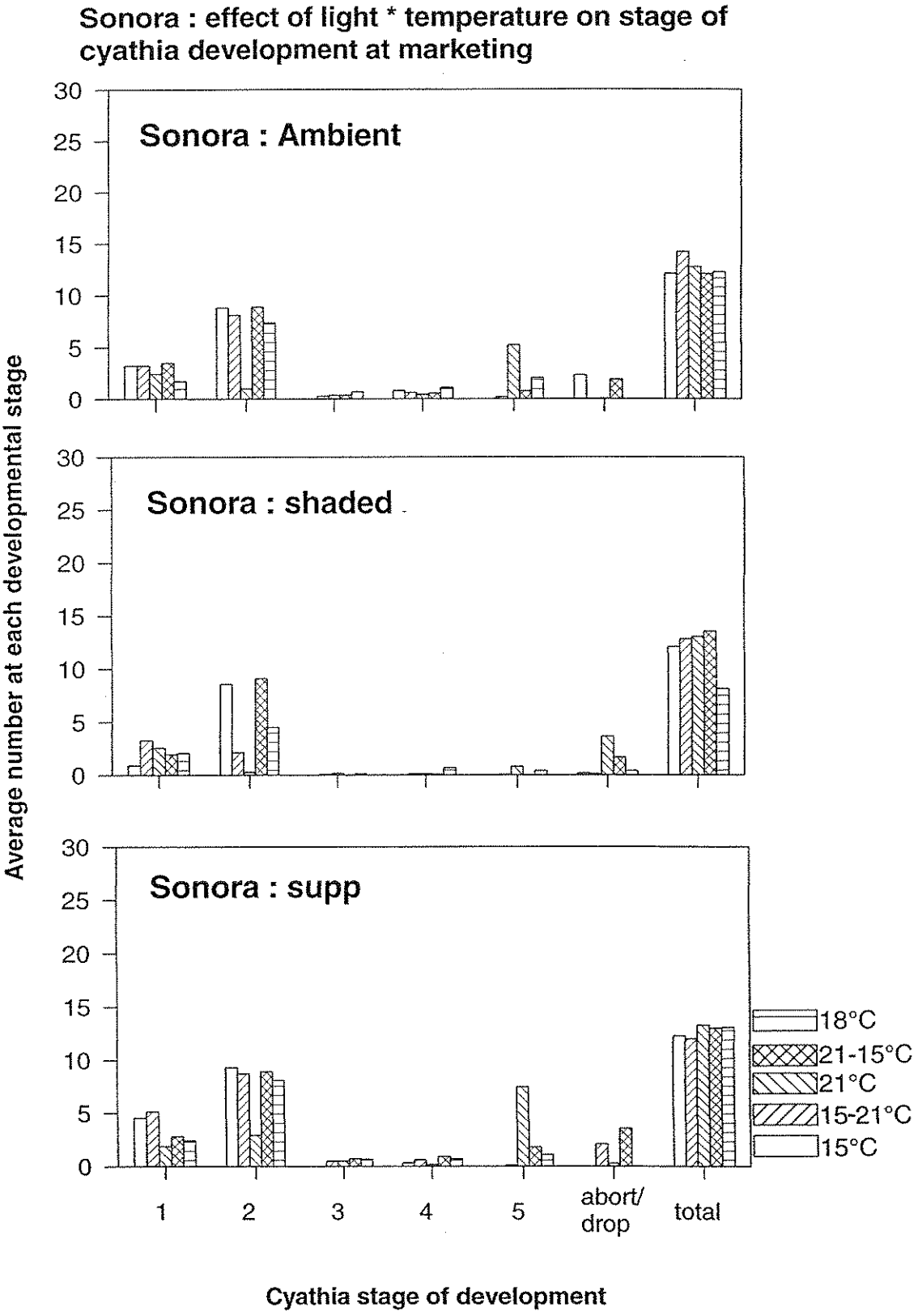


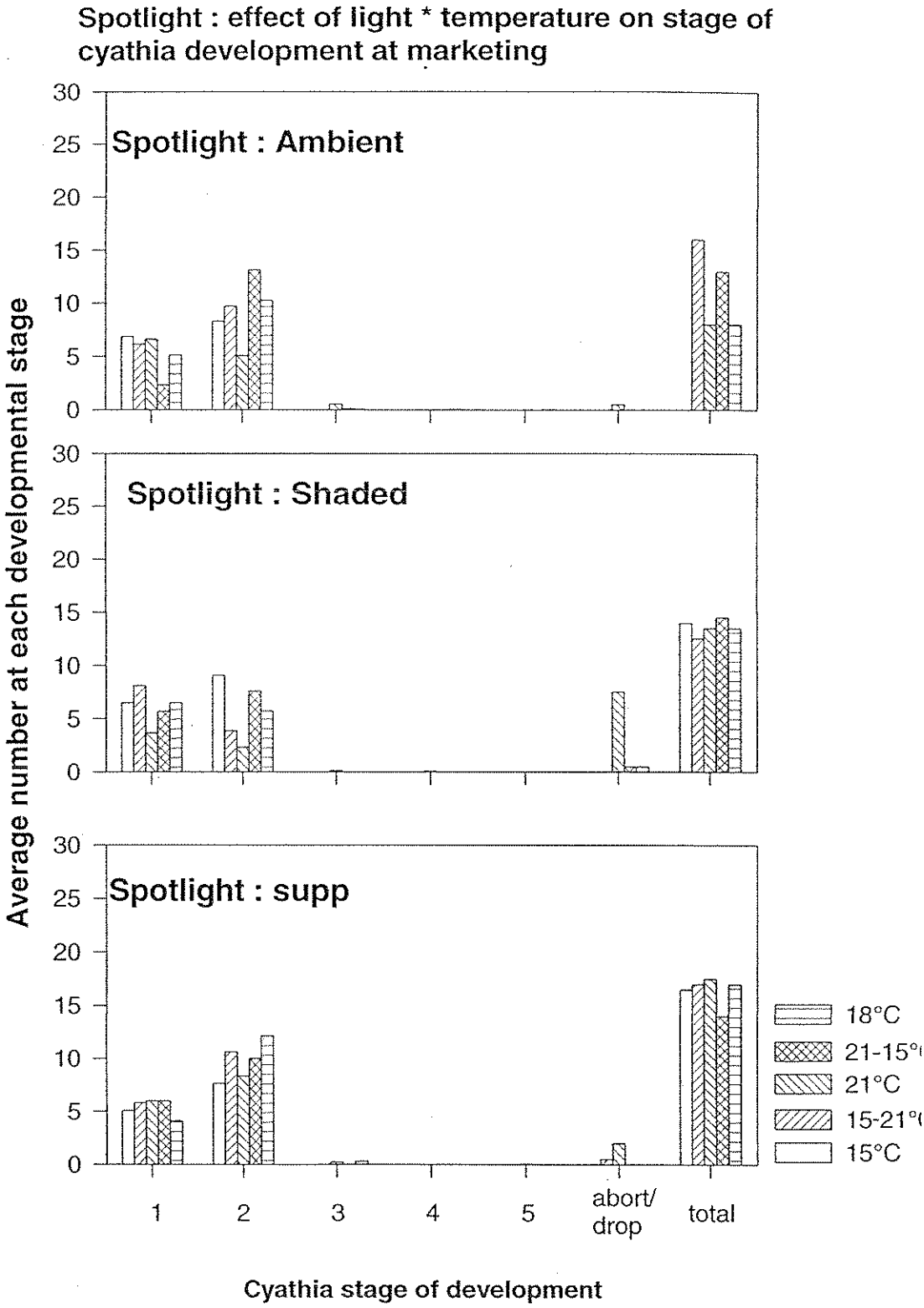


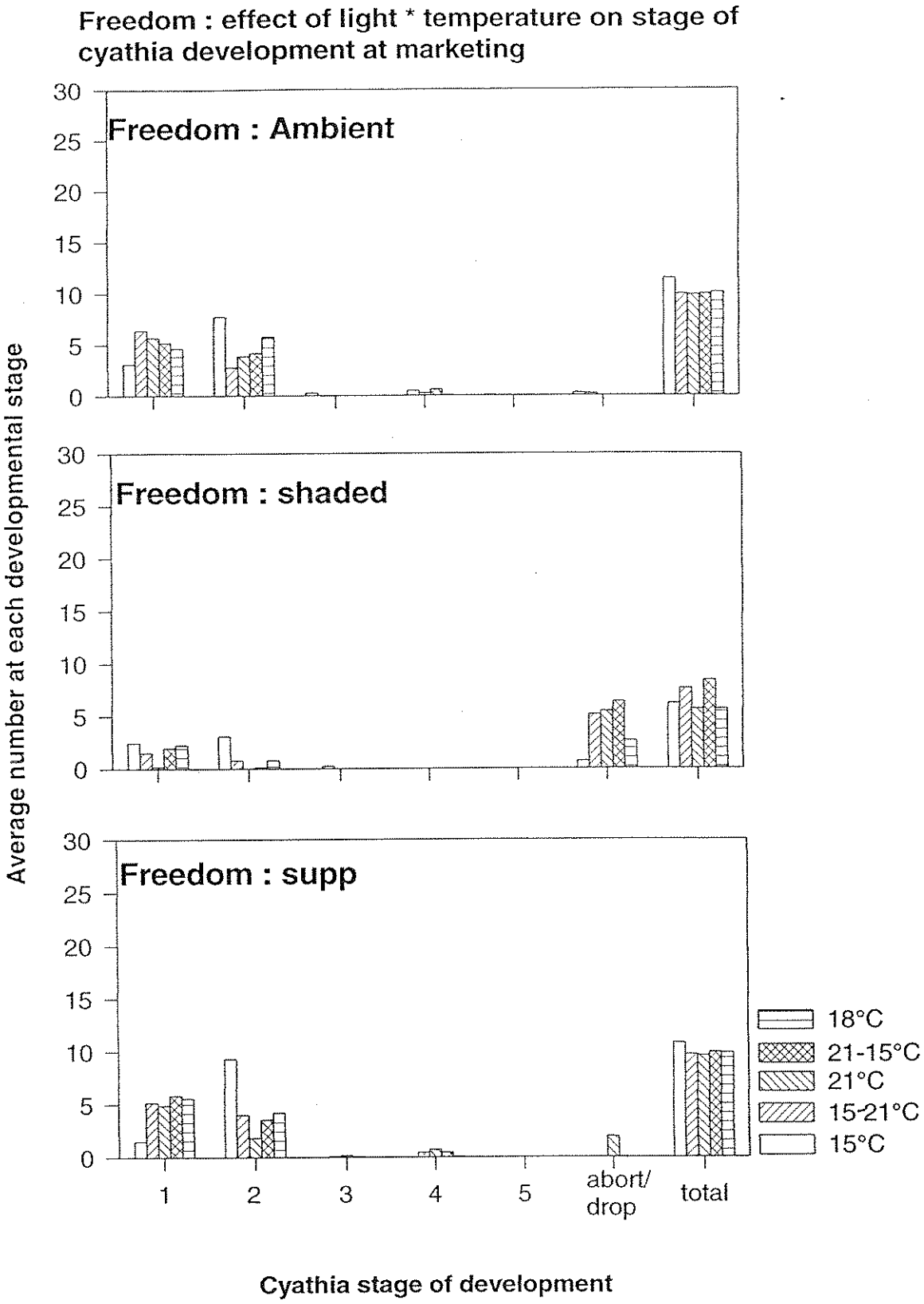


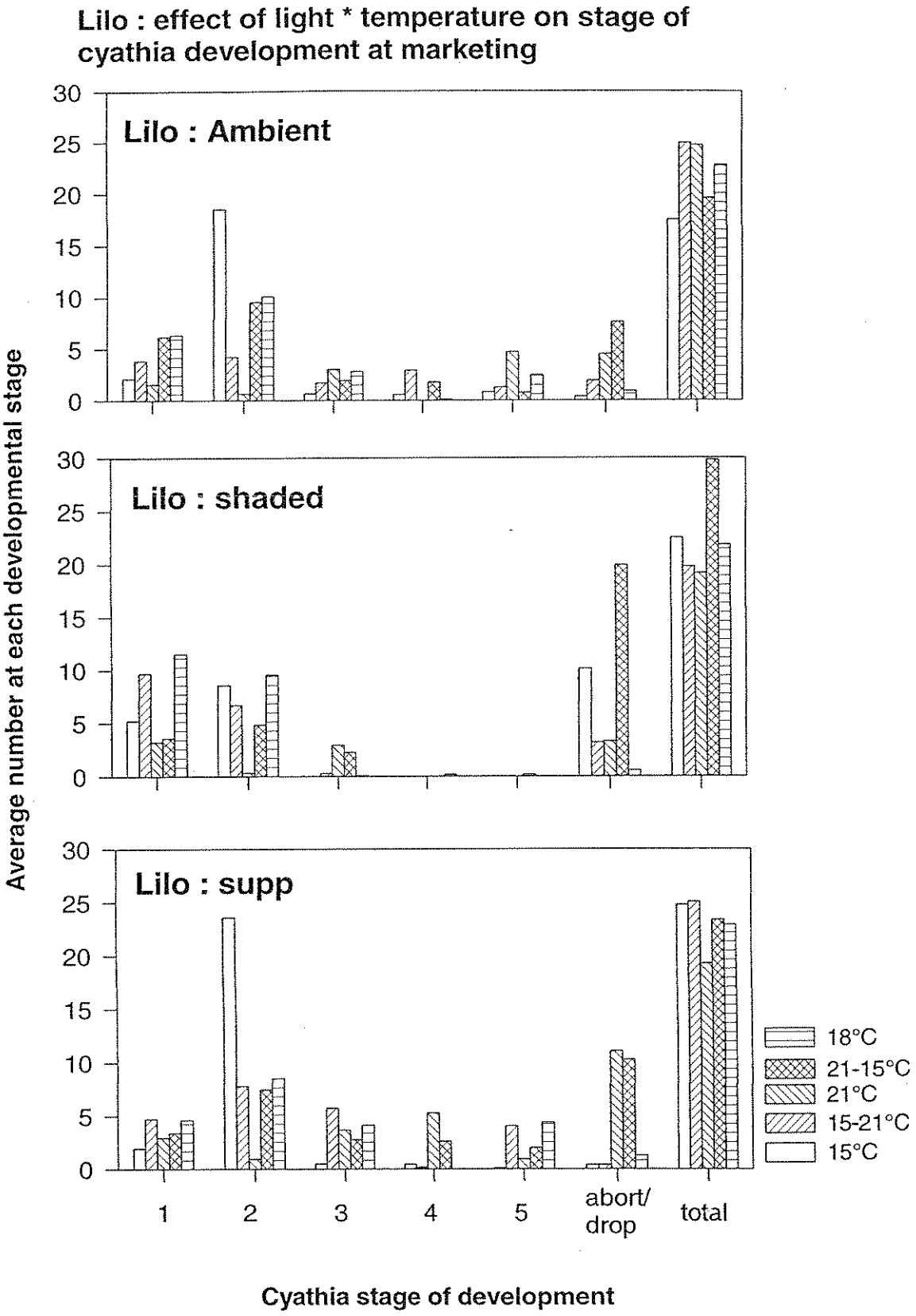




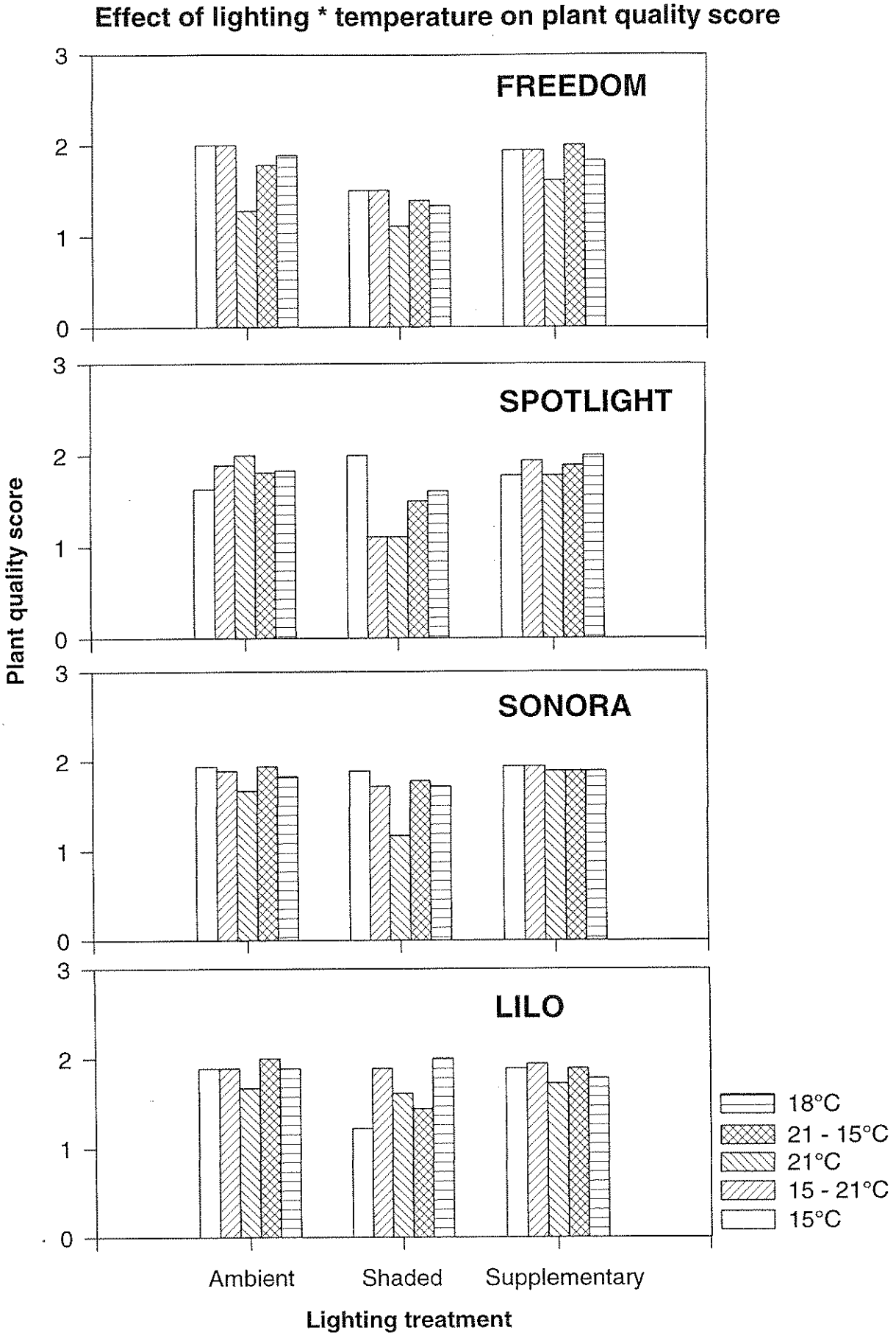








Appendix 3: Figure 10

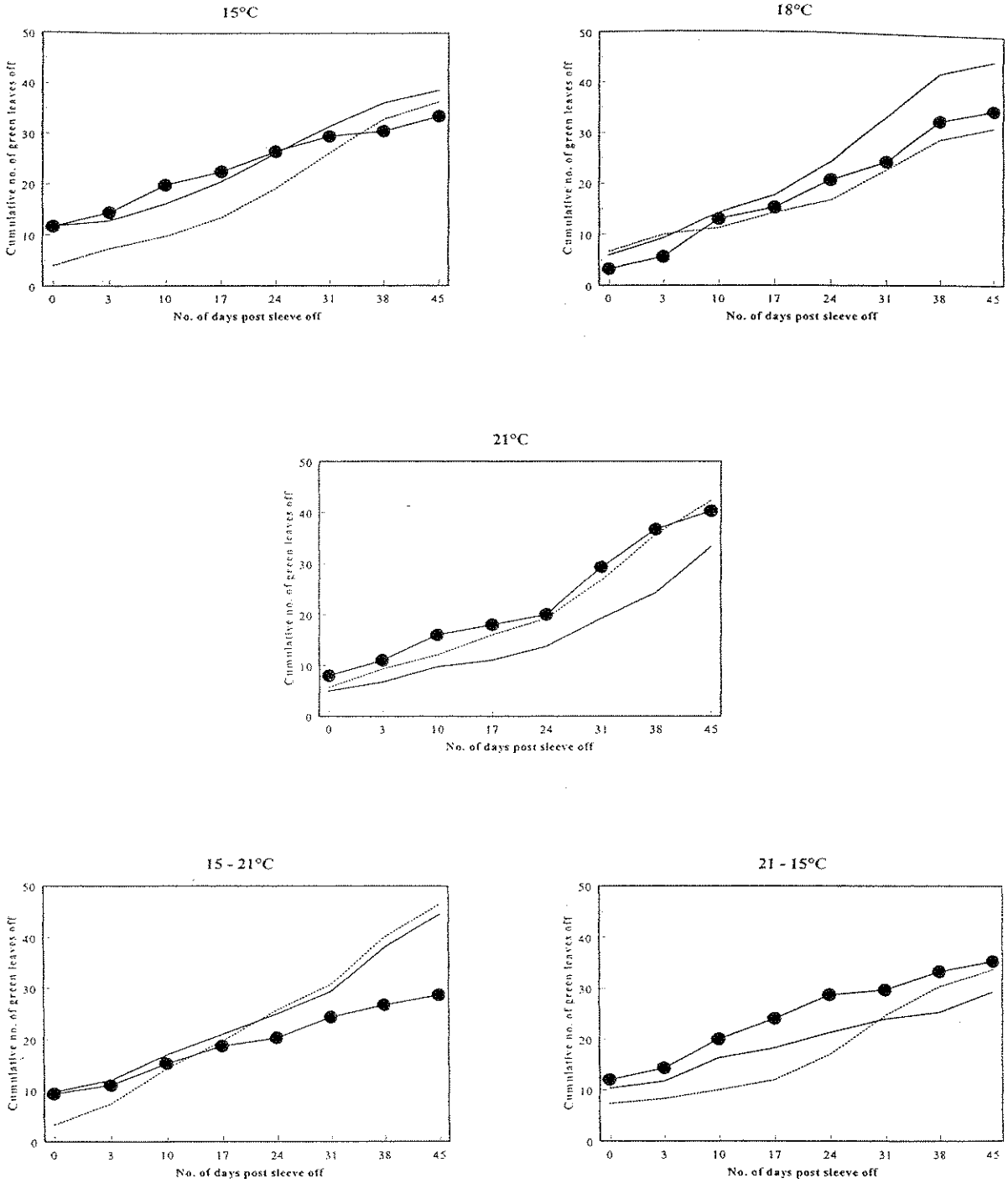


APPENDIX 4 : Shelf-life data: Observational data

Appendix 4: Figure 1

cv: Sonora

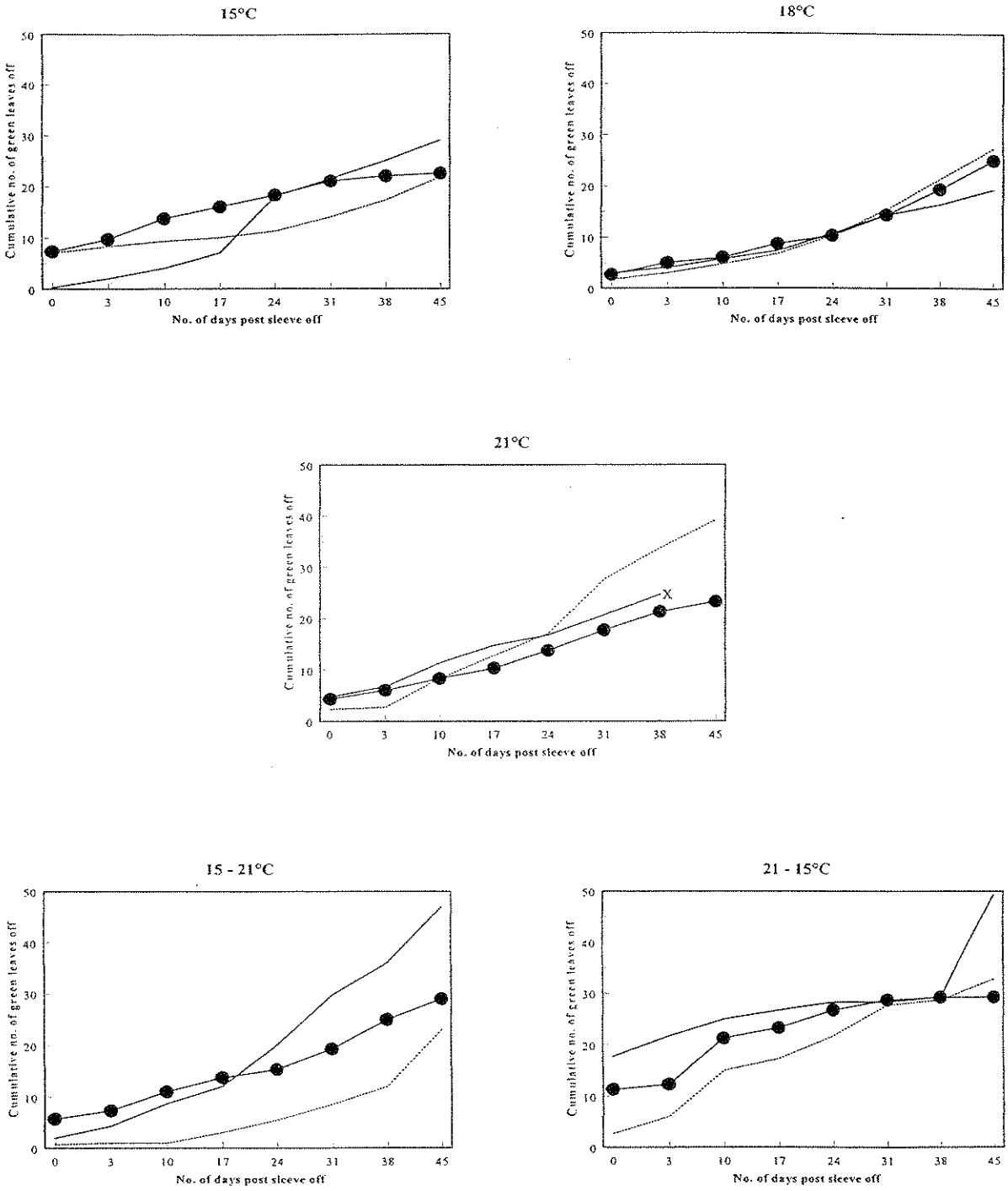
Number of green leaves fallen



Appendix 4: Figure 2

cv: Spotlight

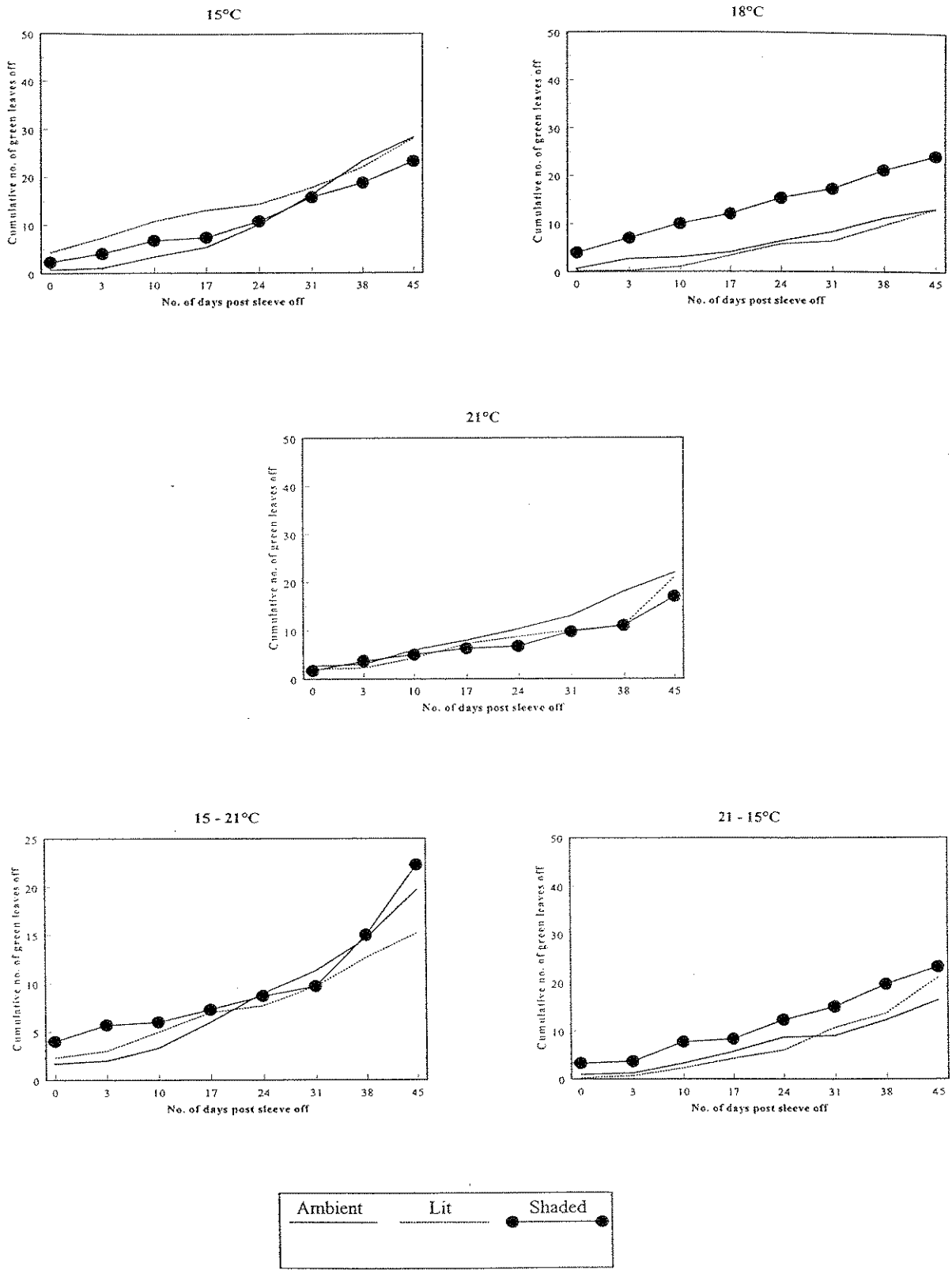
Number of green leaves fallen



Appendix 4: Figure 3

cv: Lilo

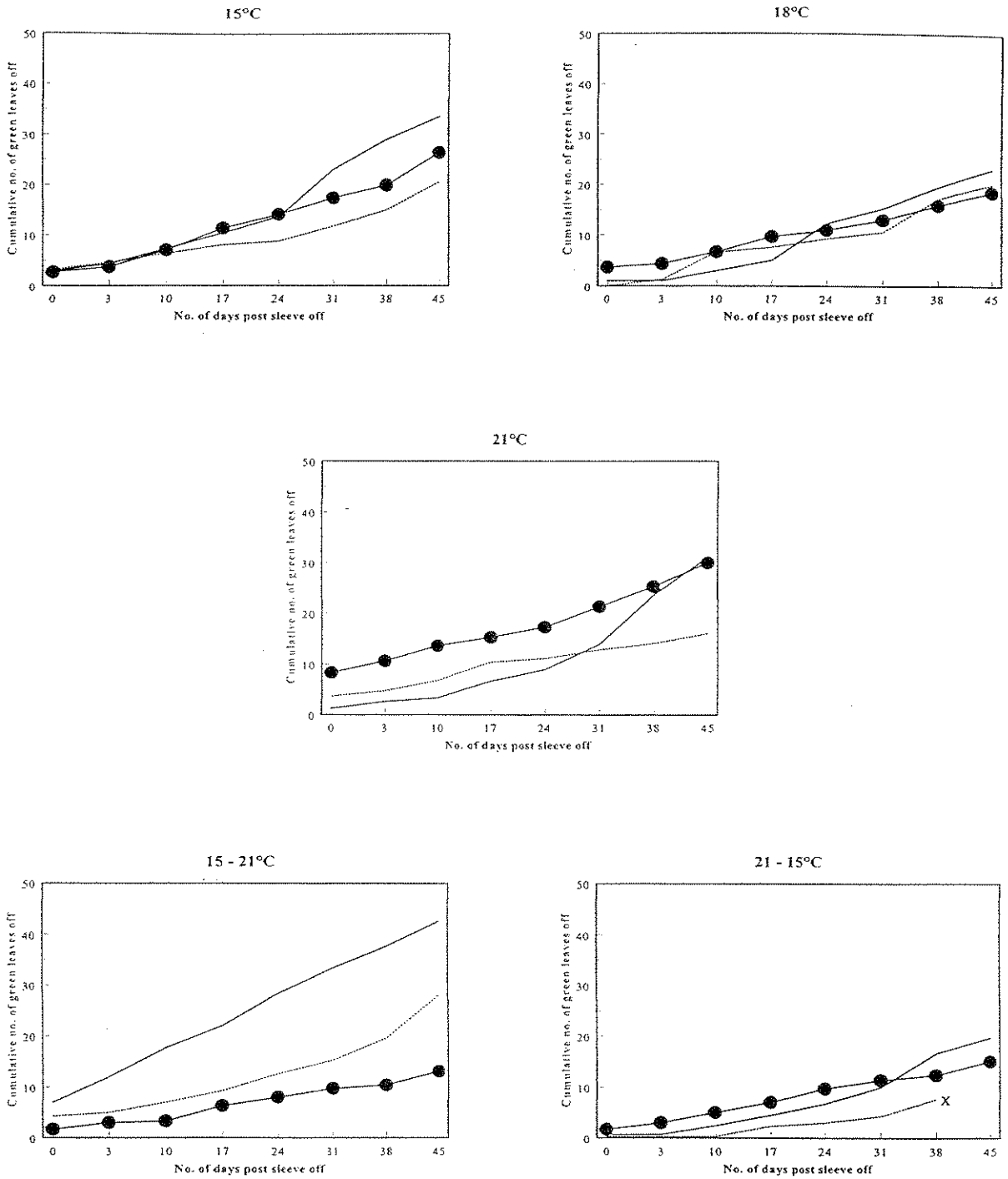
Number of green leaves fallen



Appendix 4: Figure 4

cv: Freedom

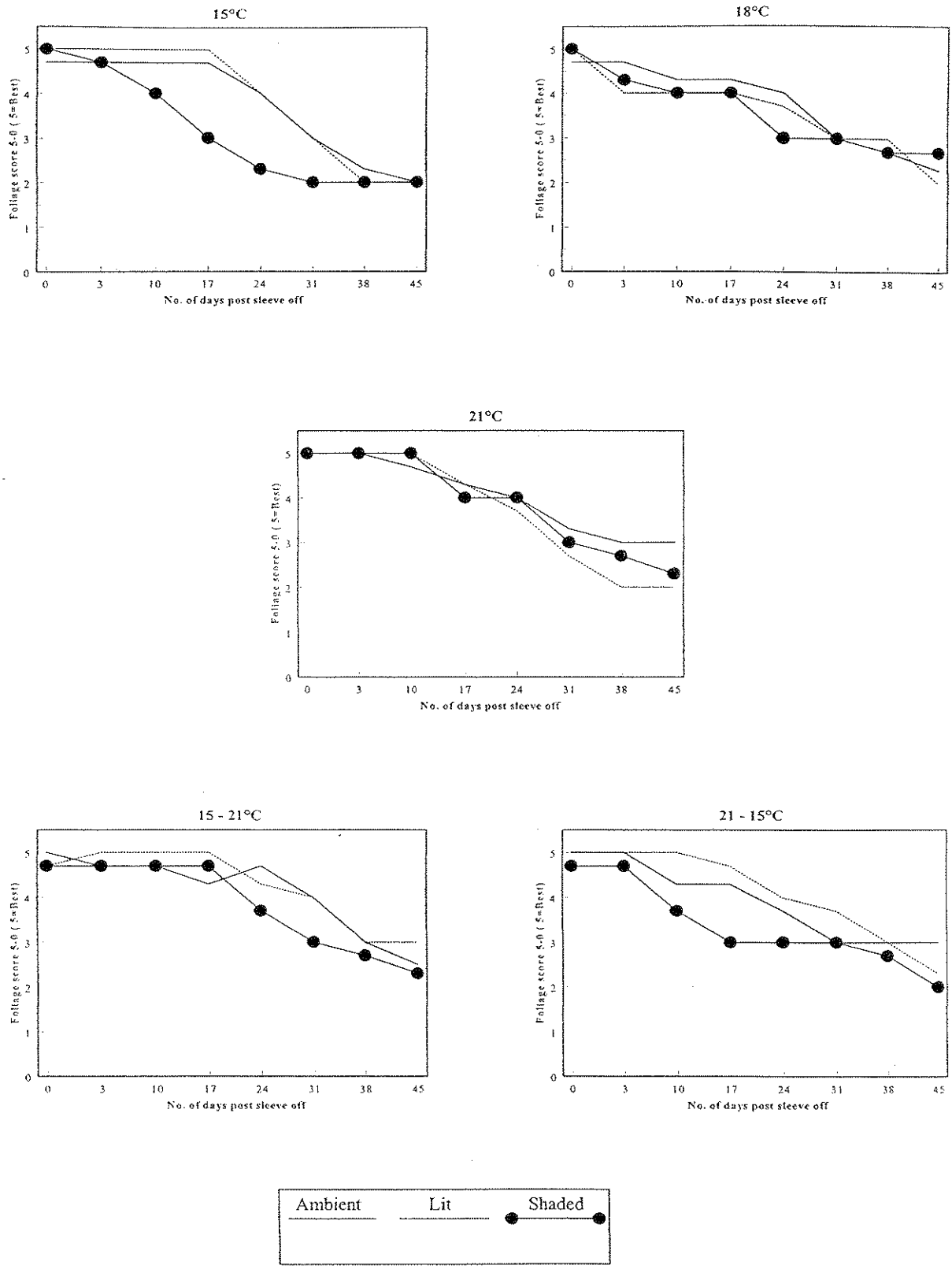
Number of green leaves fallen



Appendix 4: Figure 5

cv: Sonora

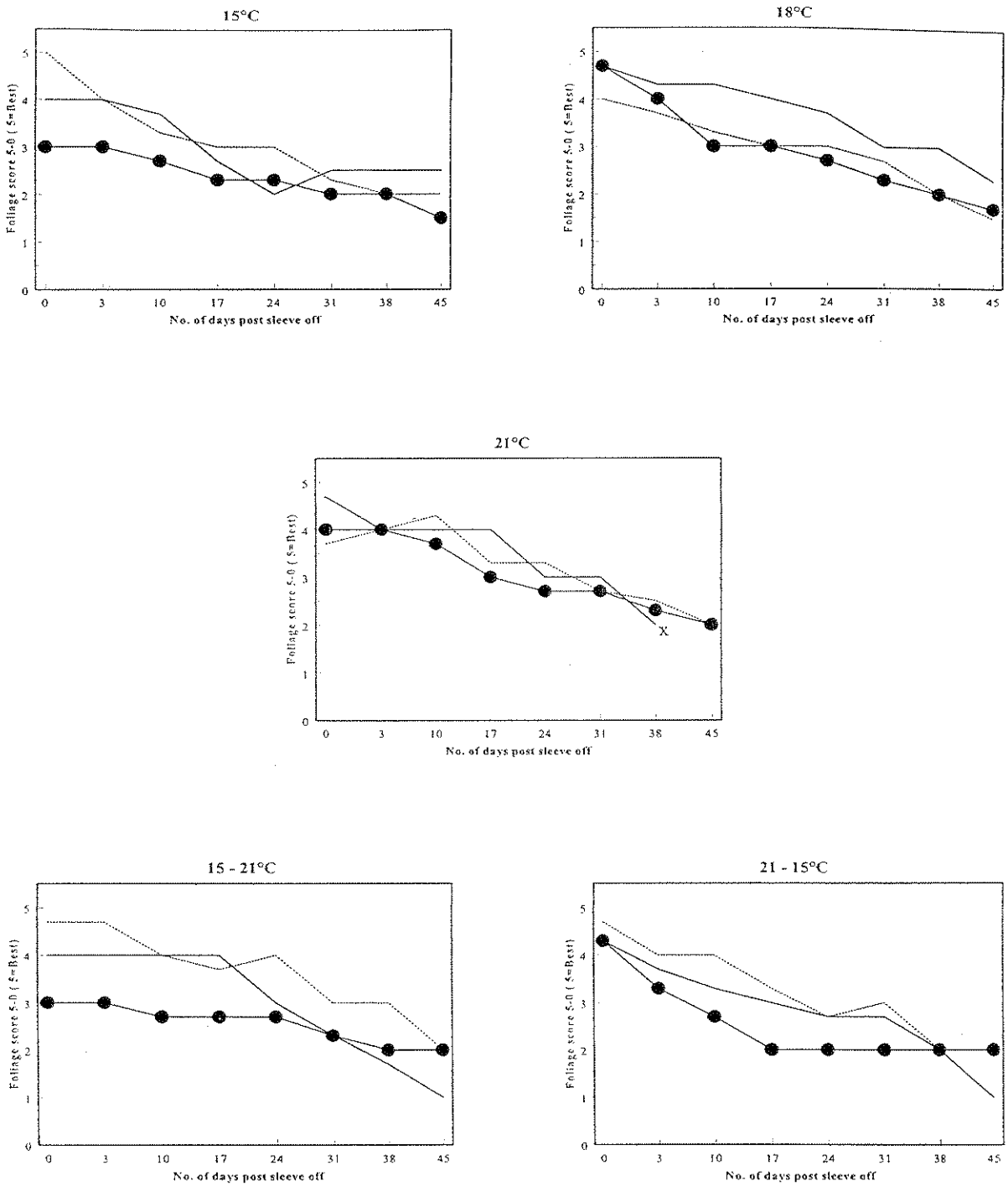
Foliage deterioration score



Appendix 4: Figure 6

cv: Spotlight

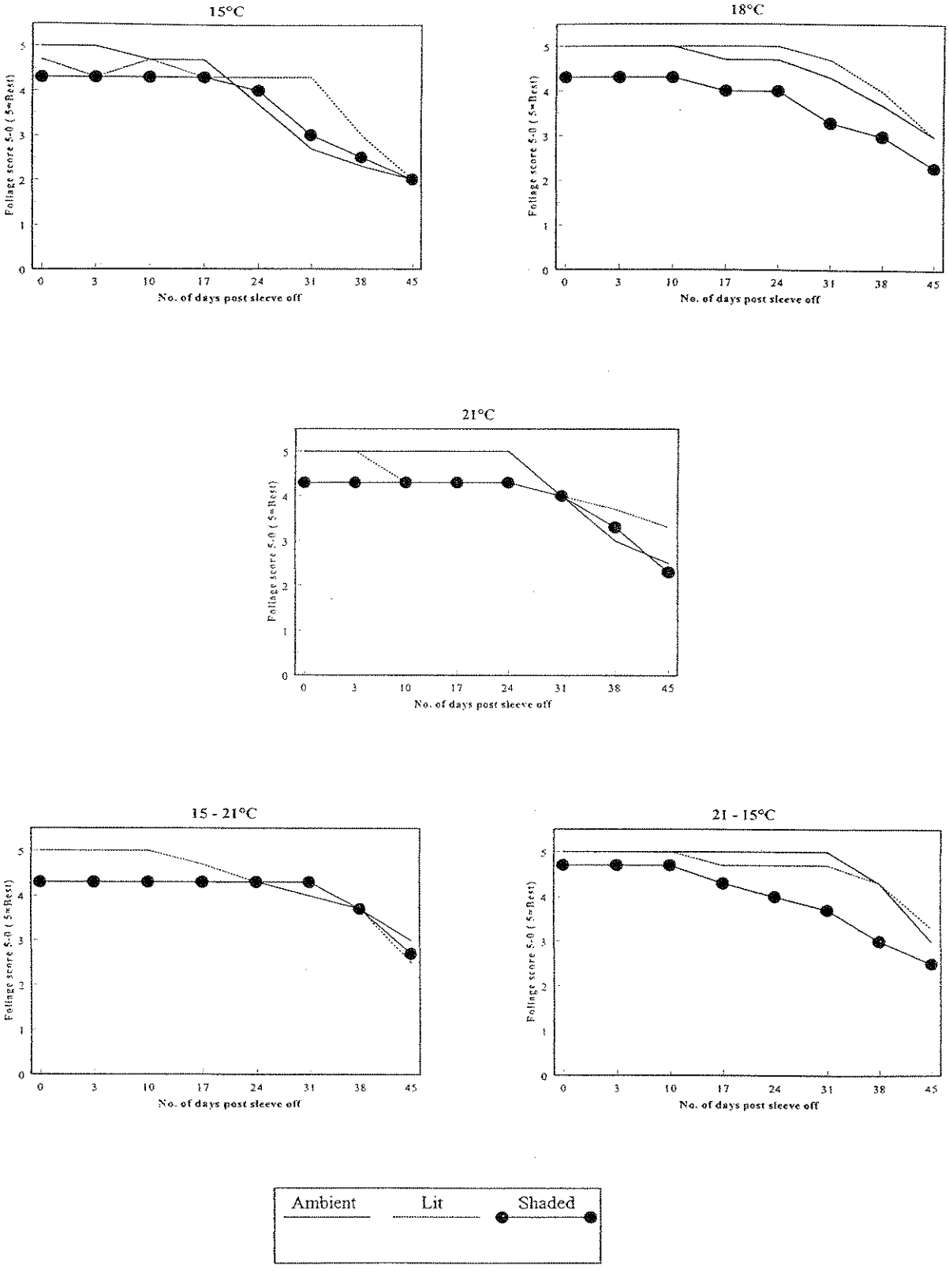
Foliage deterioration score



Appendix 4: Figure 7

cv: Lilo

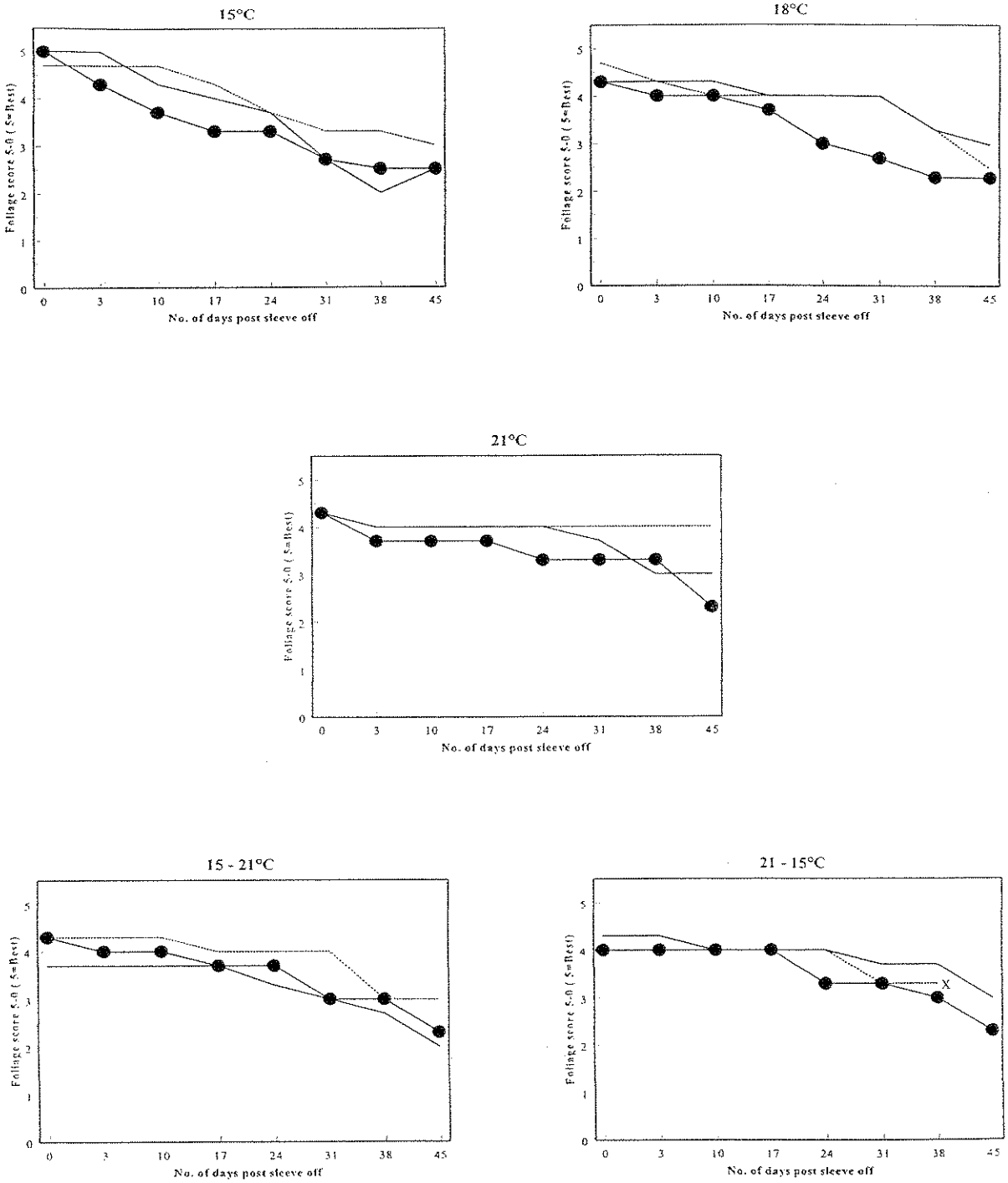
Foliage deterioration score



Appendix 4: Figure 8

cv: Freedom

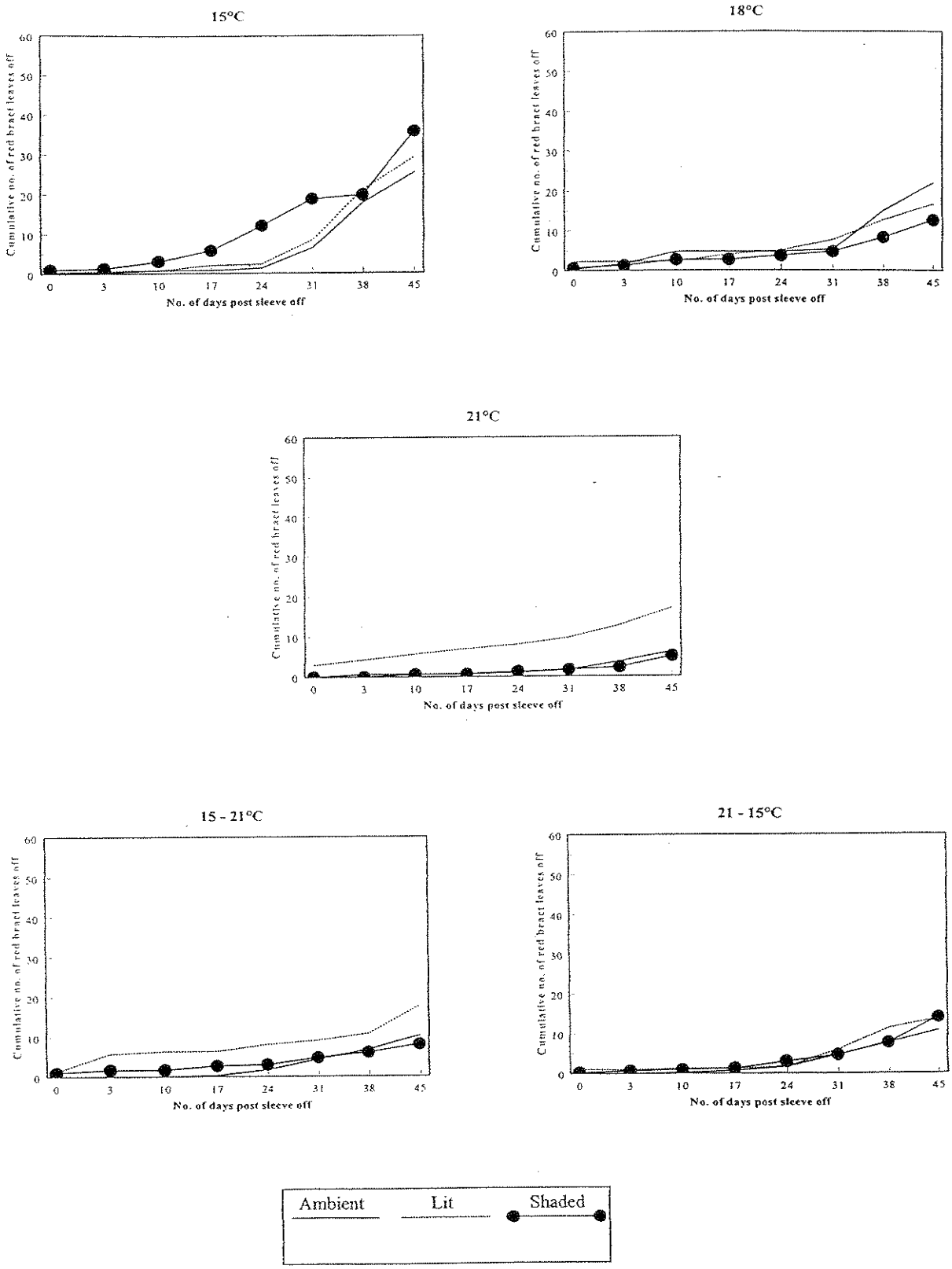
Foliage deterioration score



Appendix 4: Figure 9

cv: Sonora

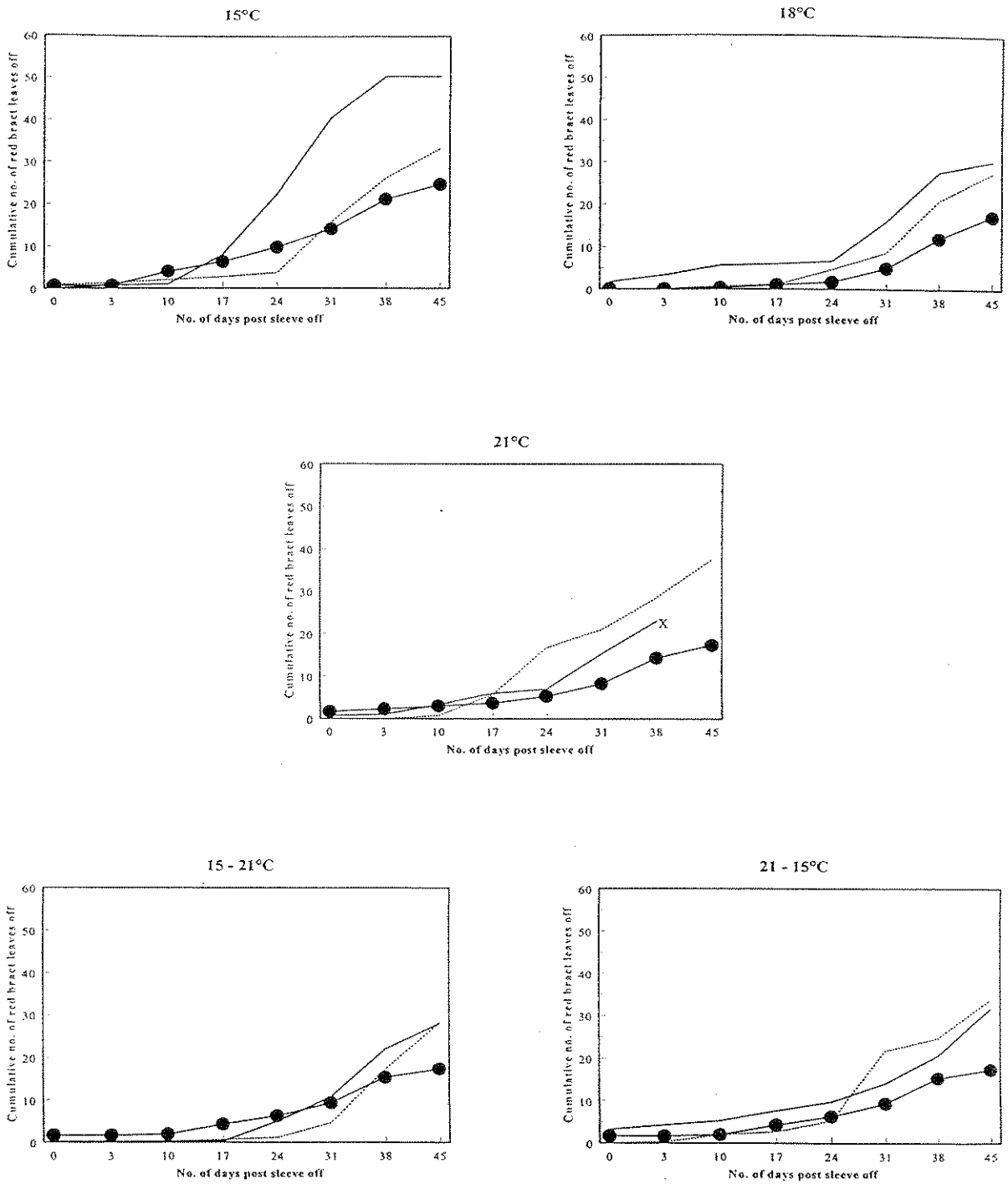
Number of red bract leaves fallen



Appendix 4: Figure 10

cv: Spotlight

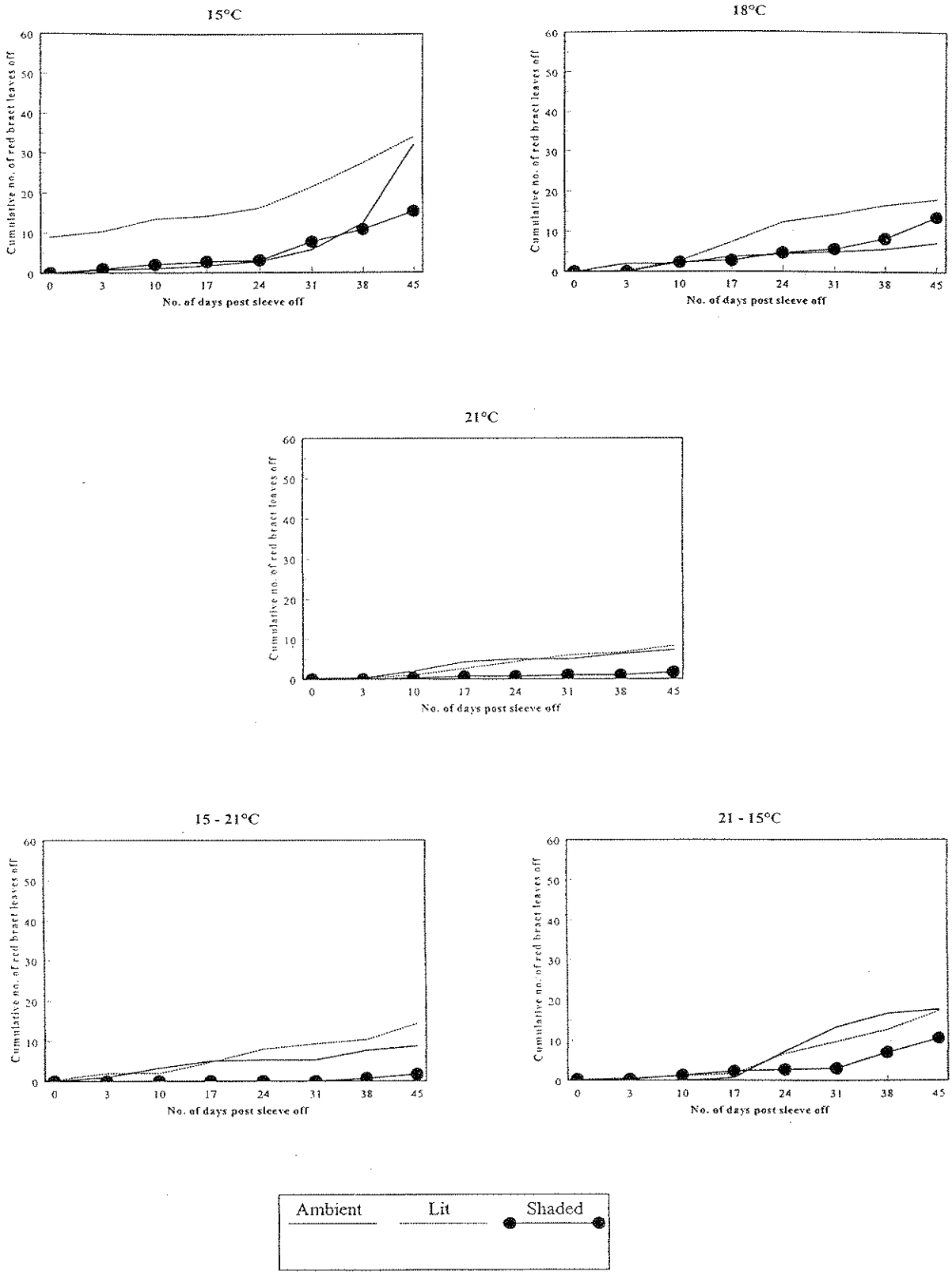
Number of red bract leaves fallen



Appendix 4: Figure 11

cv: Lilo

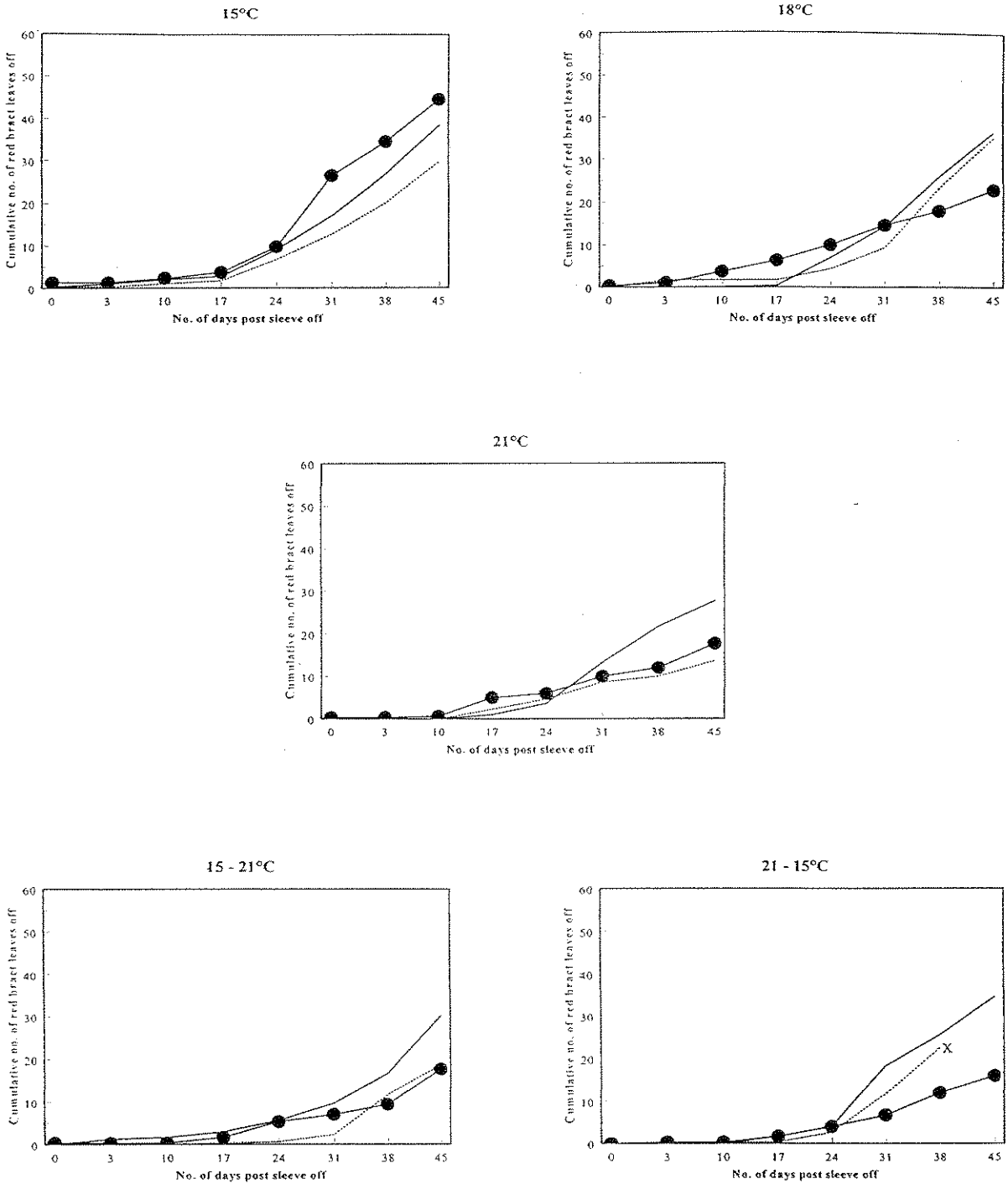
Number of red bract leaves fallen



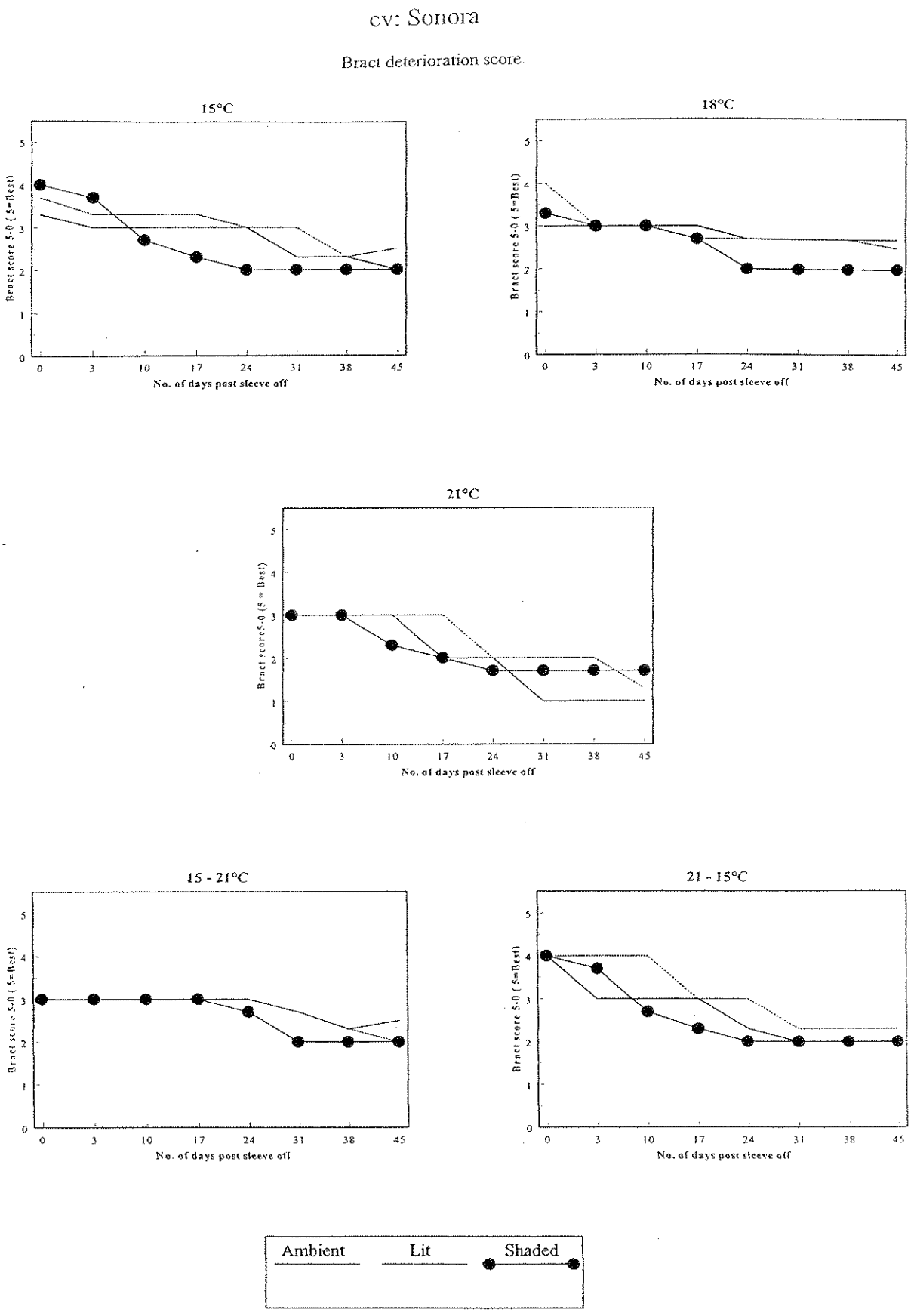
Appendix 4: Figure 12

cv: Freedom

Number of red bract leaves fallen



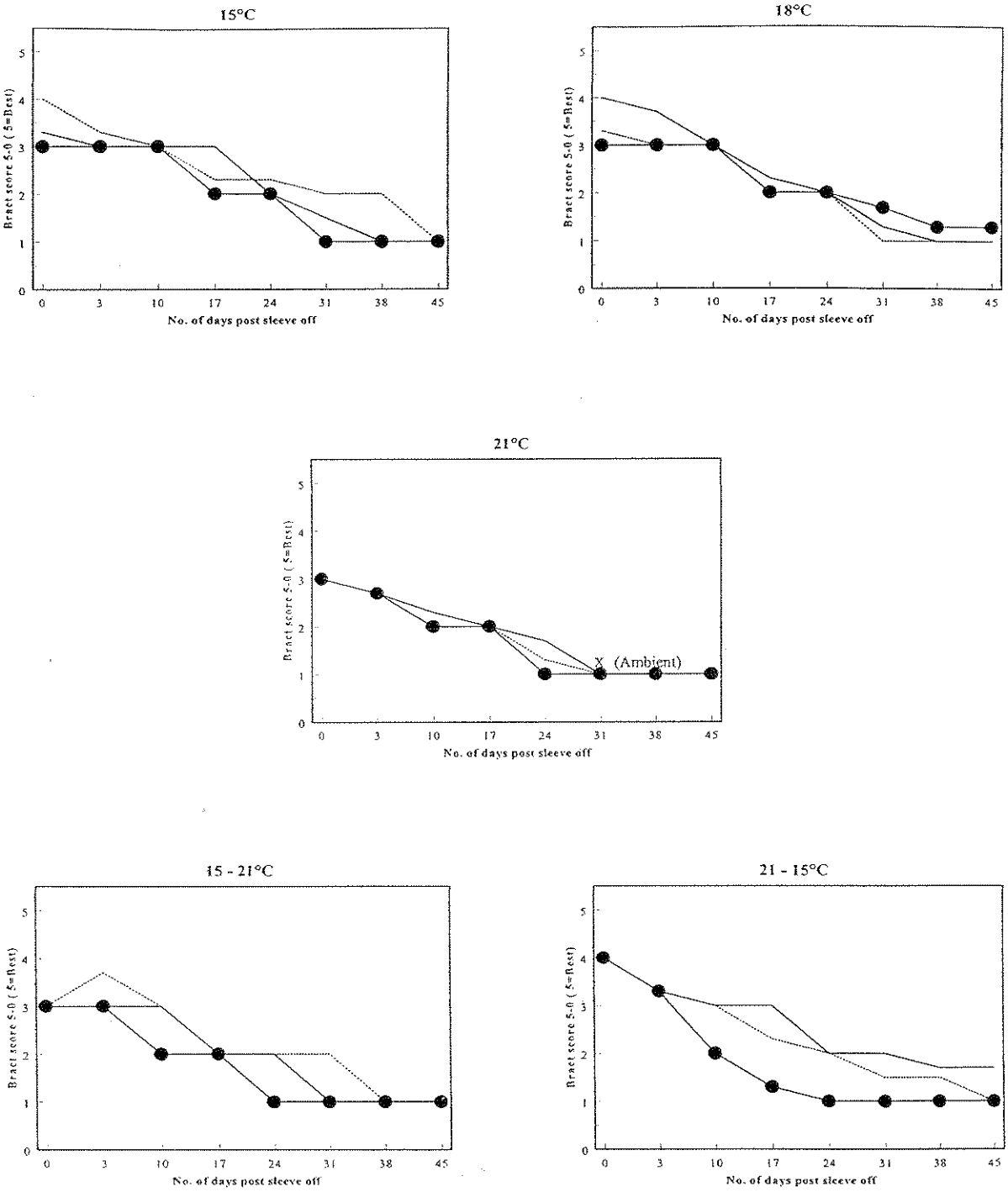
Appendix 4: Figure 13



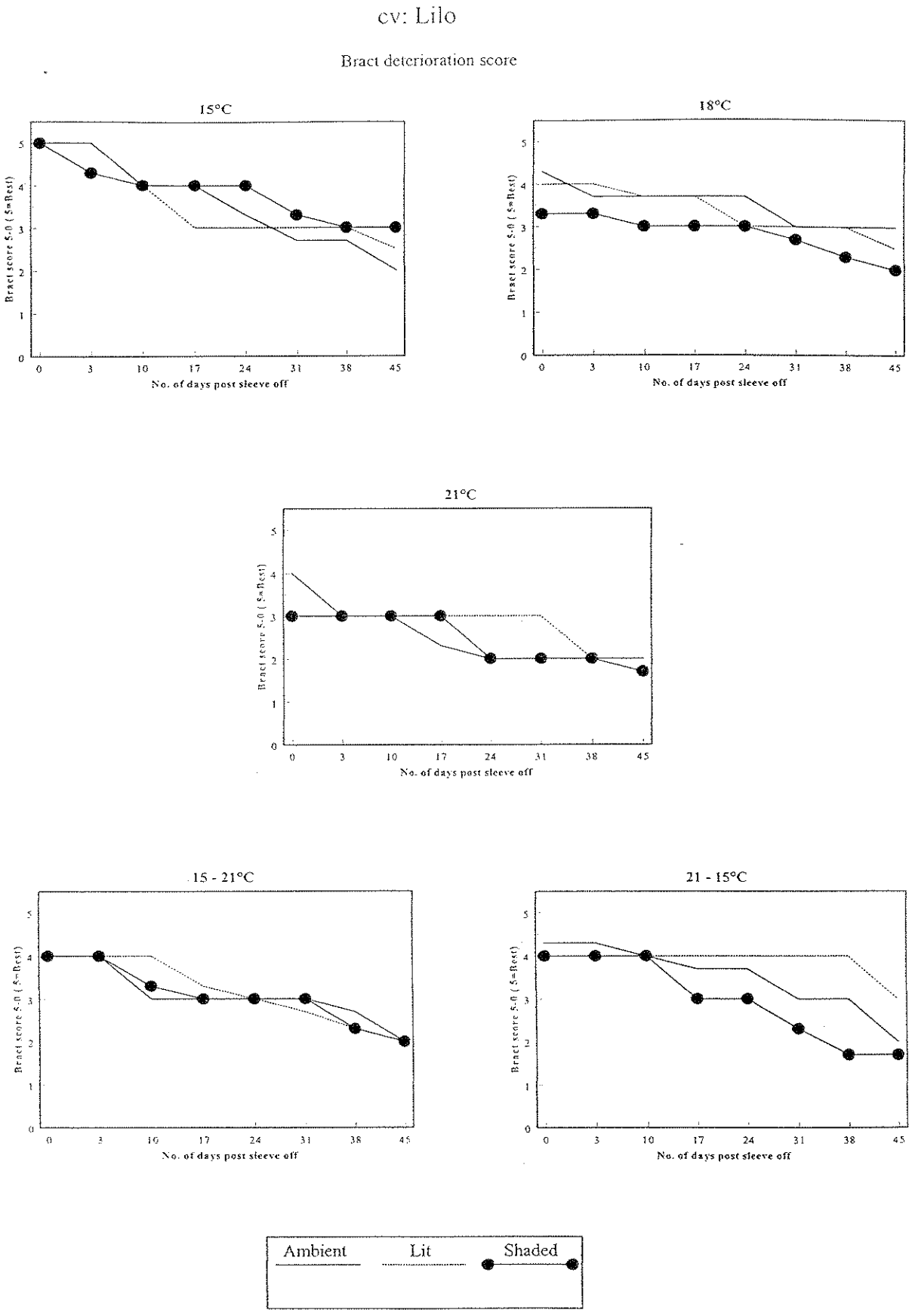
Appendix 4: Figure 14

cv: Spotlight

Bract deterioration score



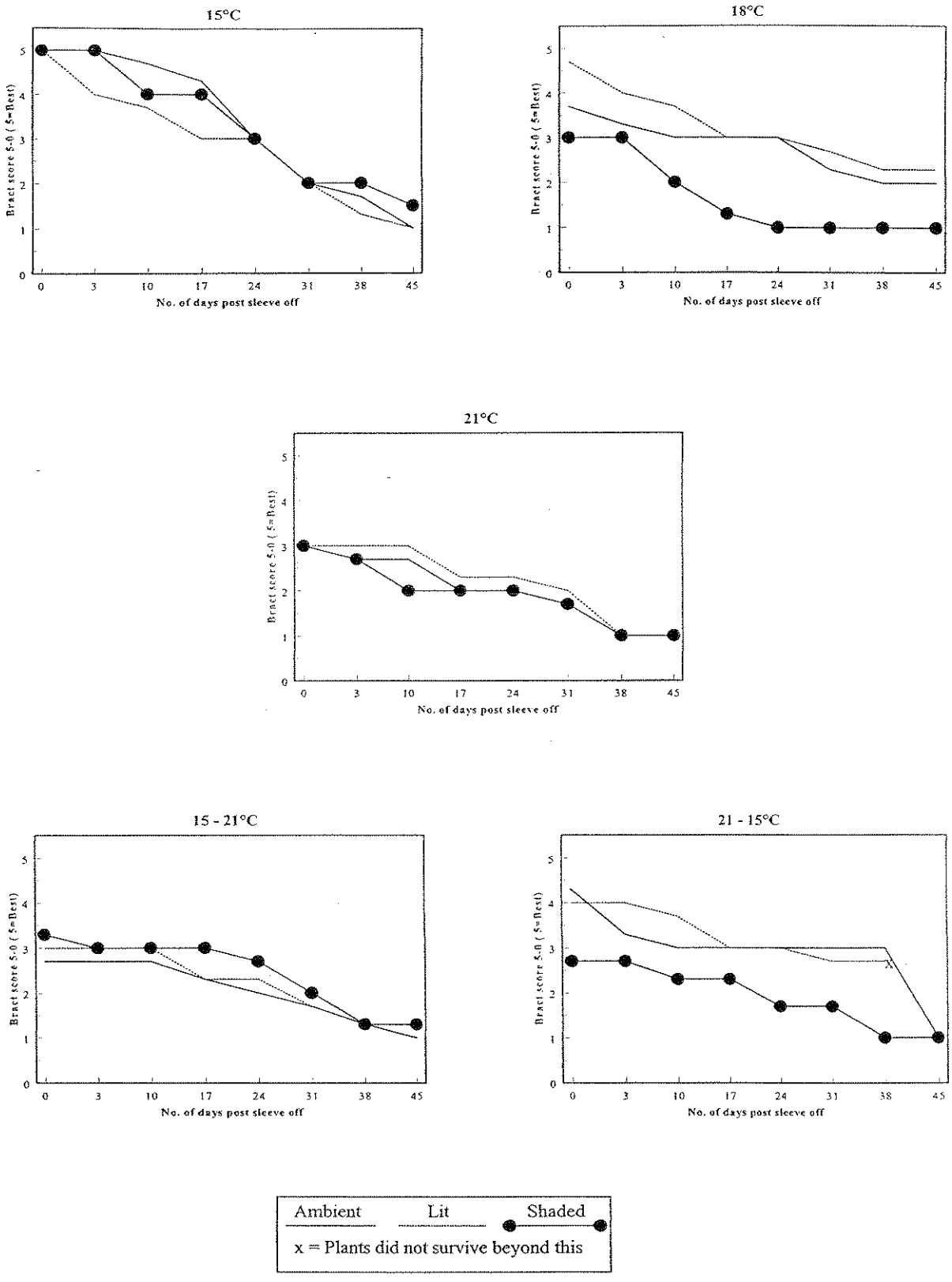
Appendix 4: Figure 15



Appendix 4: Figure 16

cv: Freedom

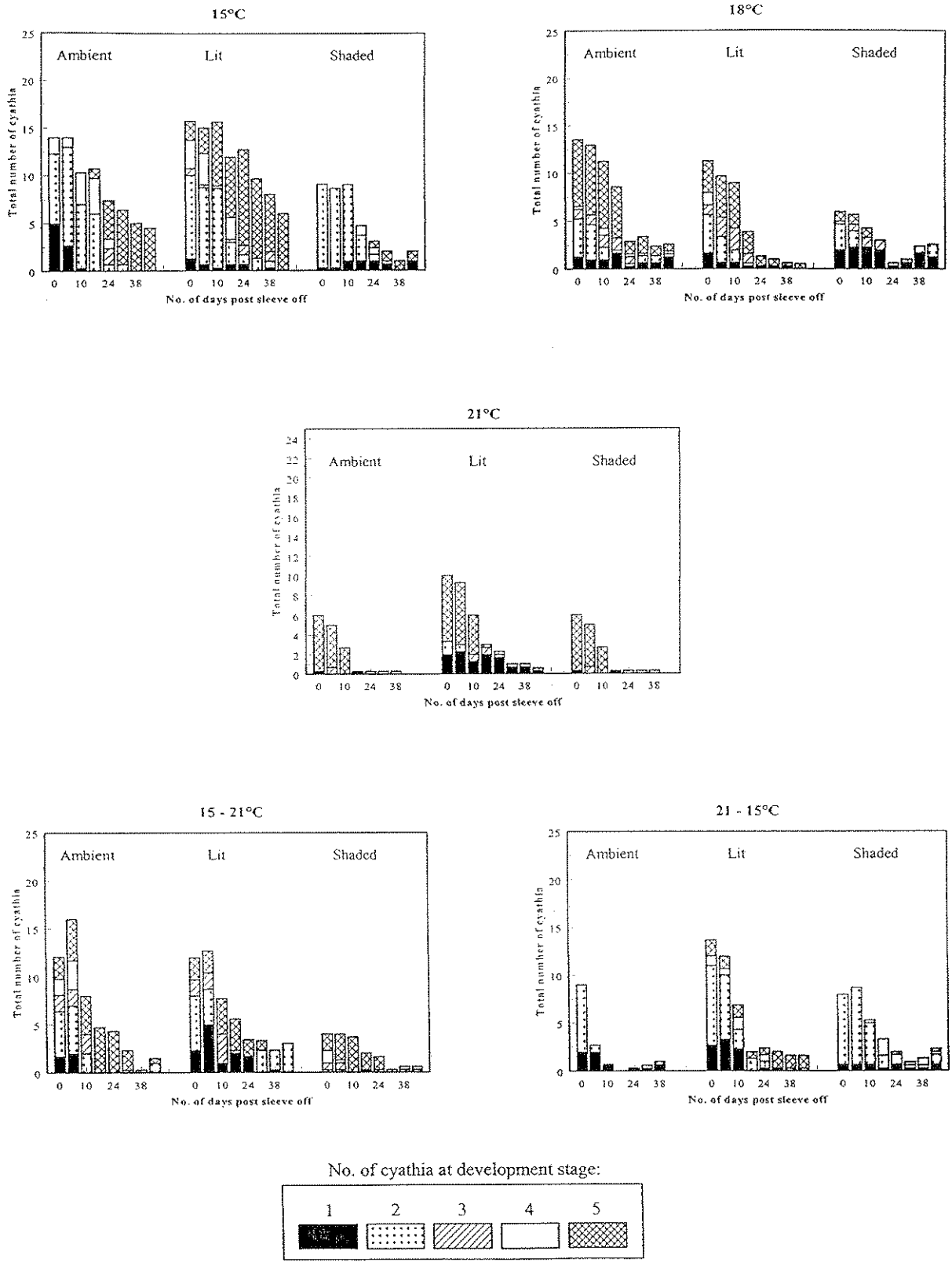
Bract deterioration score



Appendix 4: Figure 17

cv: Sonora

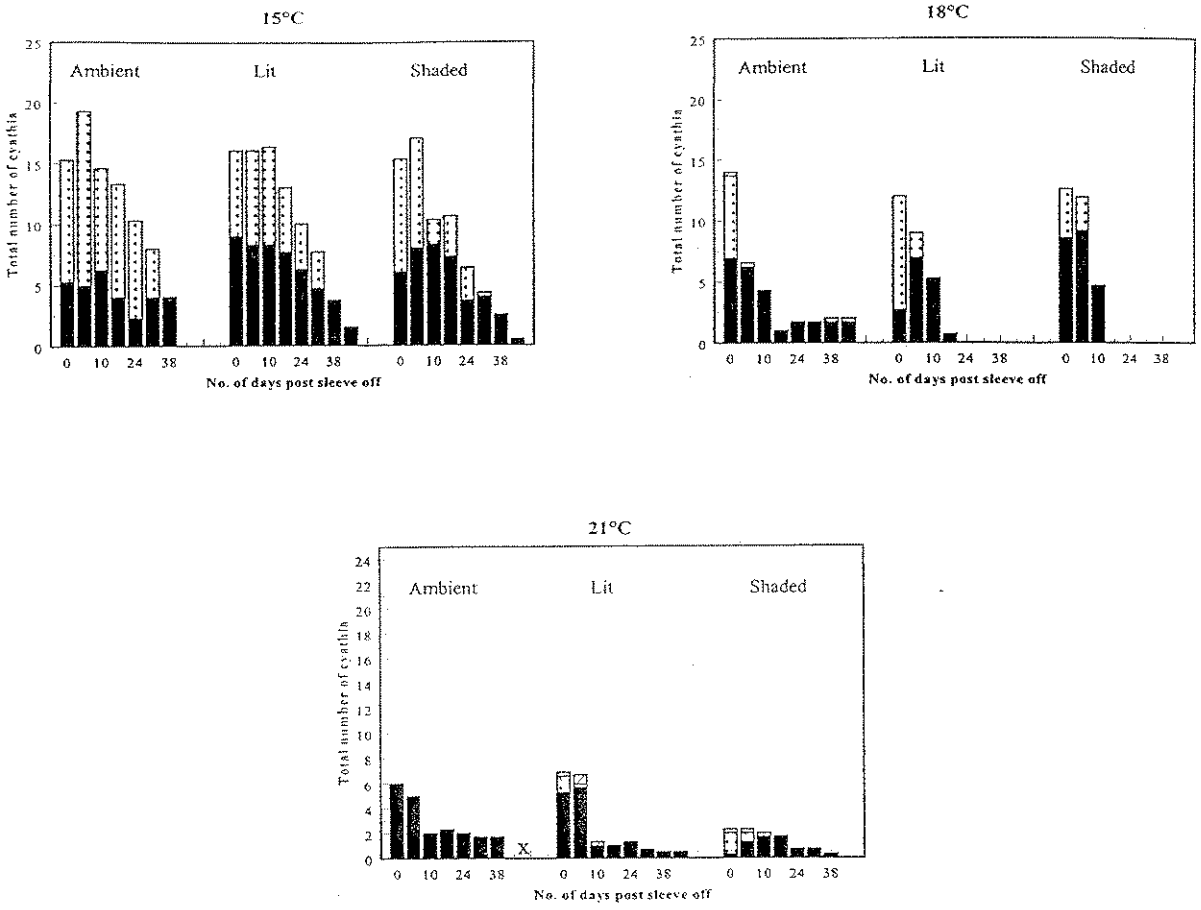
Cyathia development/loss



Appendix 4: Figure 18

cv: Spotlight

Cyathia development/loss



No. of cyathia at development stage:

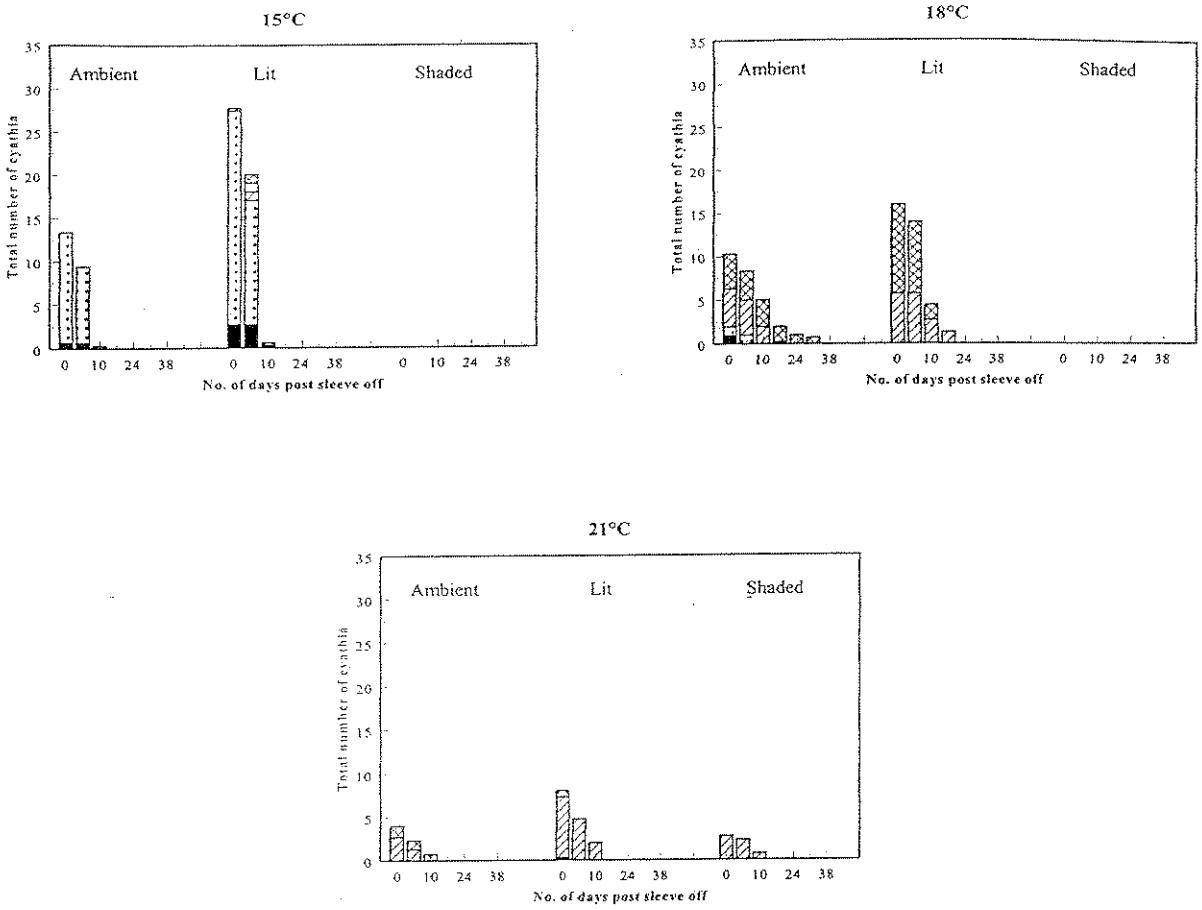
1 2 3 4 5

x = Plants did not survive beyond this

Appendix 4: Figure 19

cv: Lilo

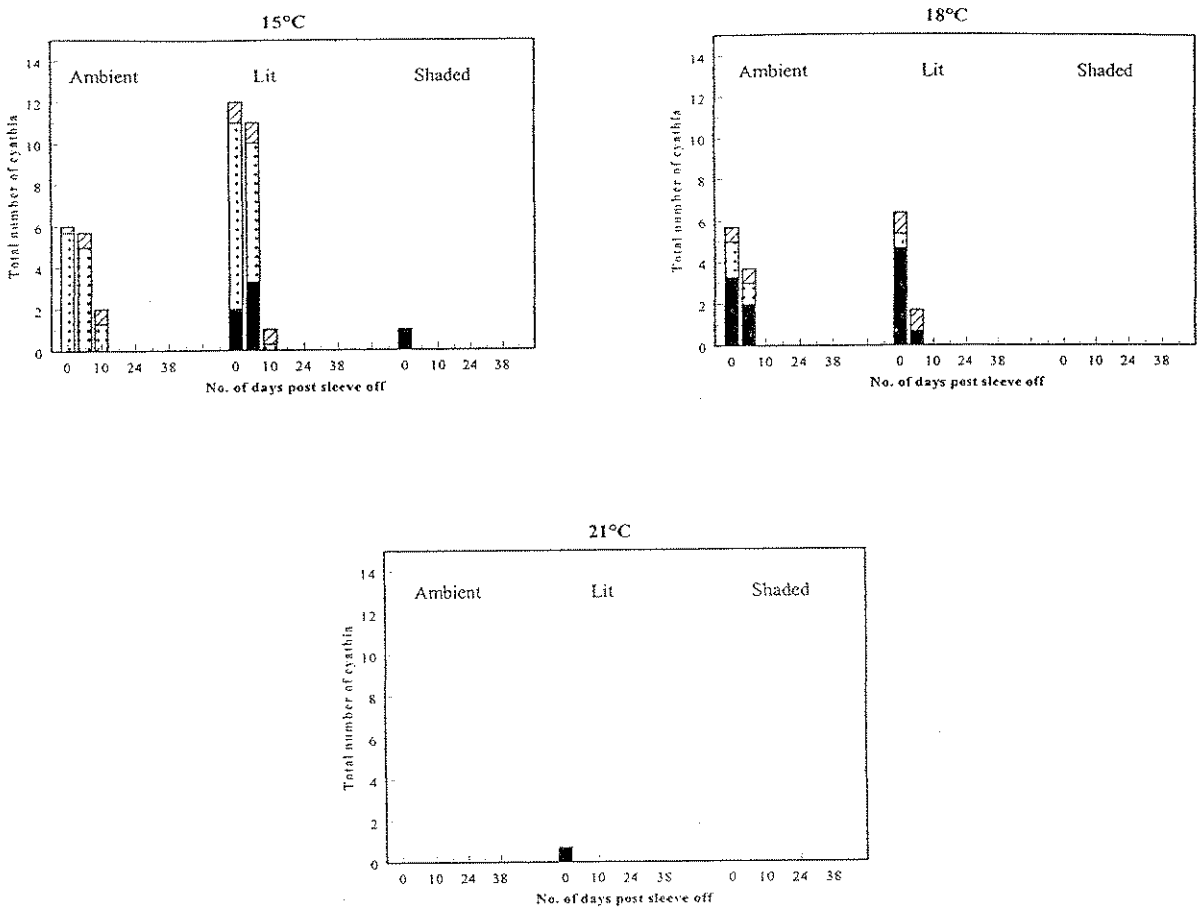
Cyathia development/loss



Appendix 4: Figure 20

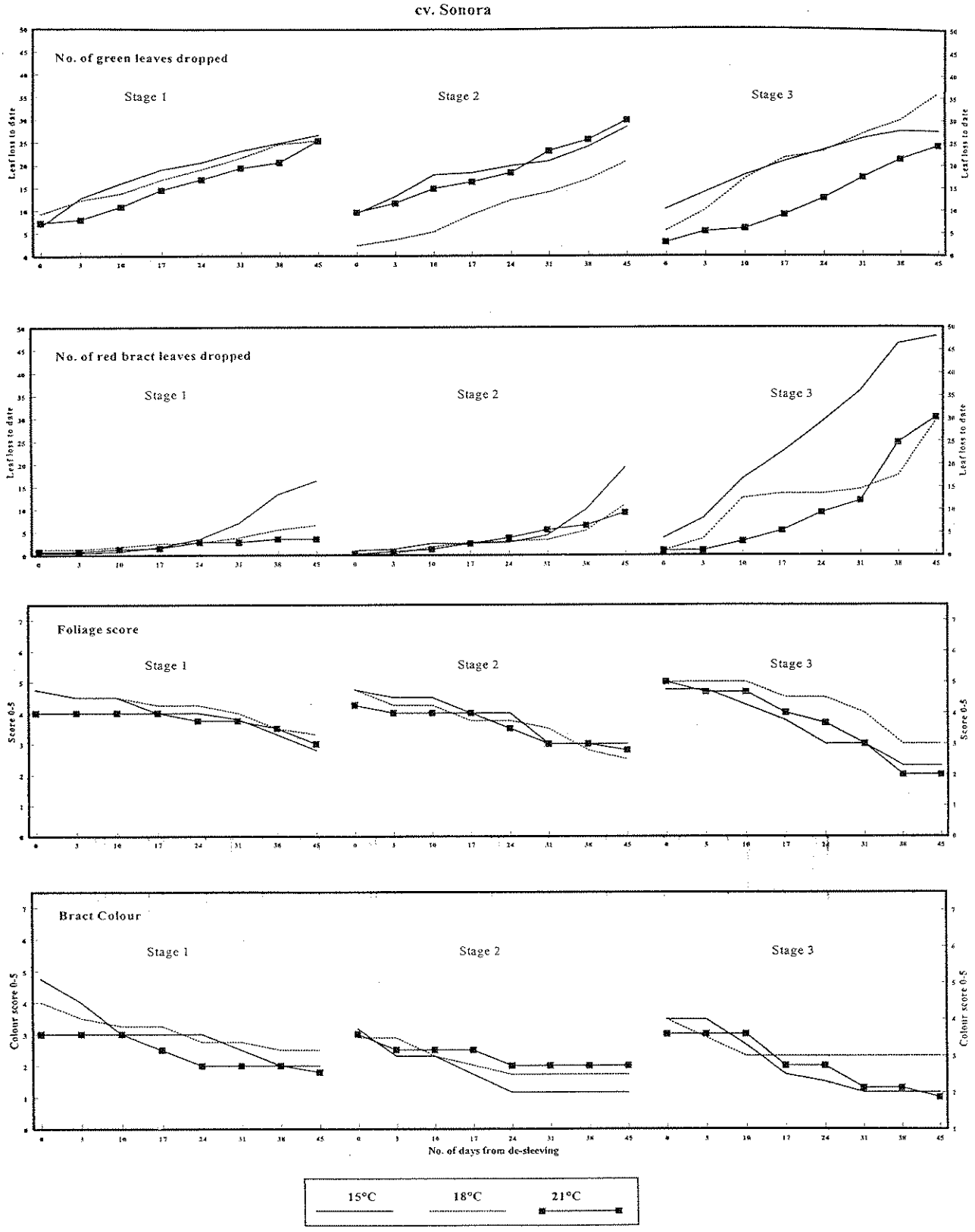
cv: Freedom

Cyathia development/loss

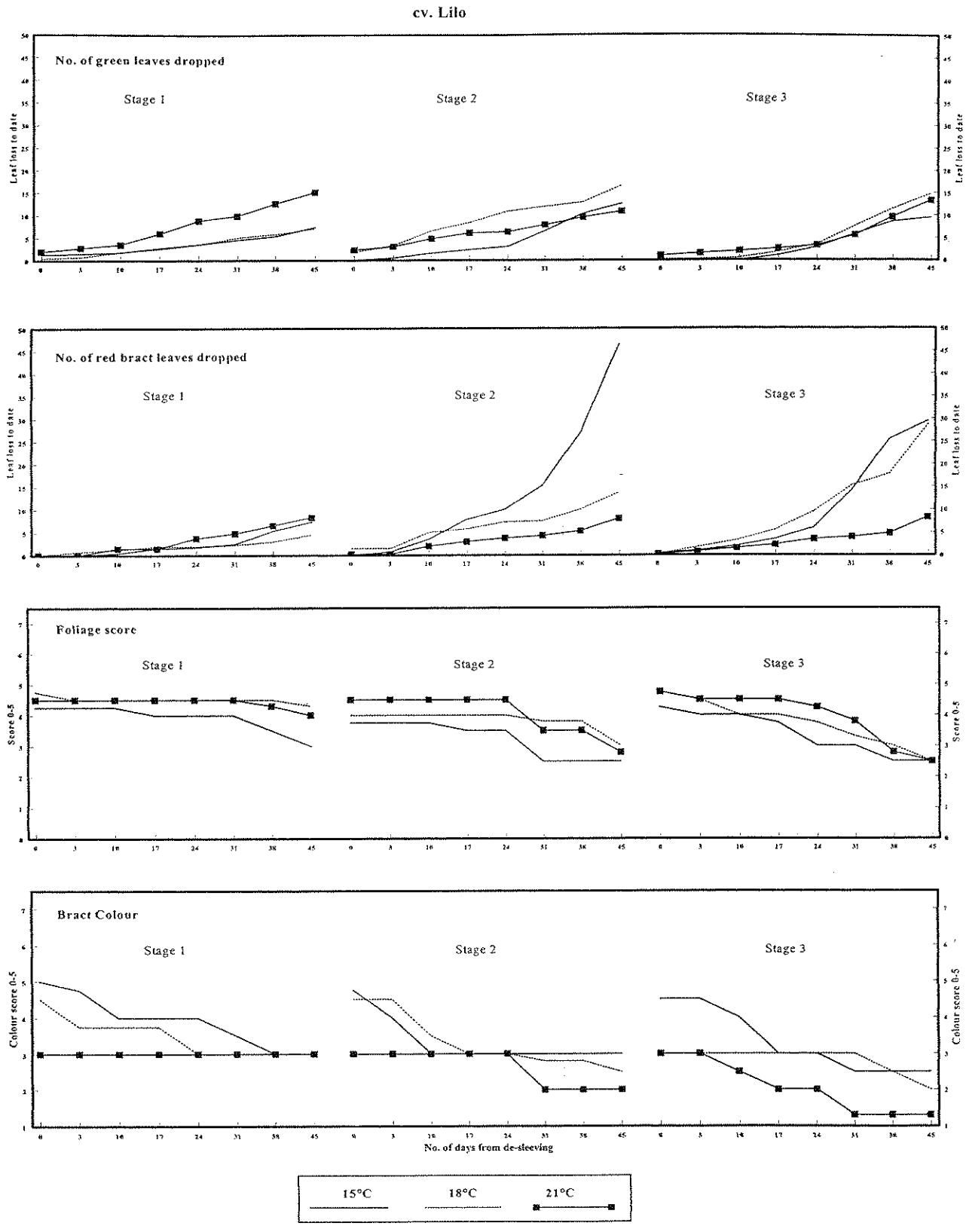


APPENDIX 5 : Shelf-life data: Effect of marketing stage

Appendix 5: Figure 1

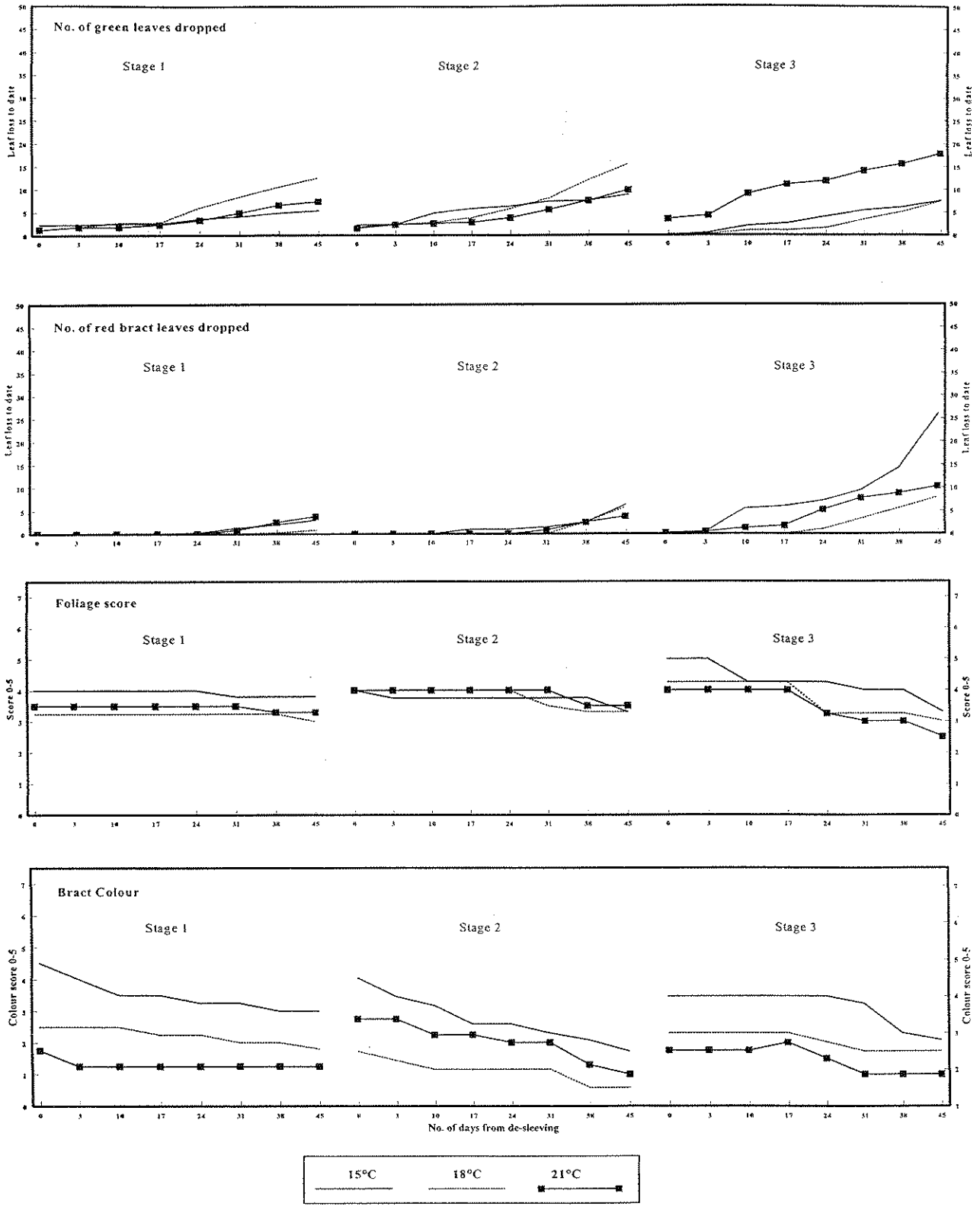


Appendix 5: Figure 3

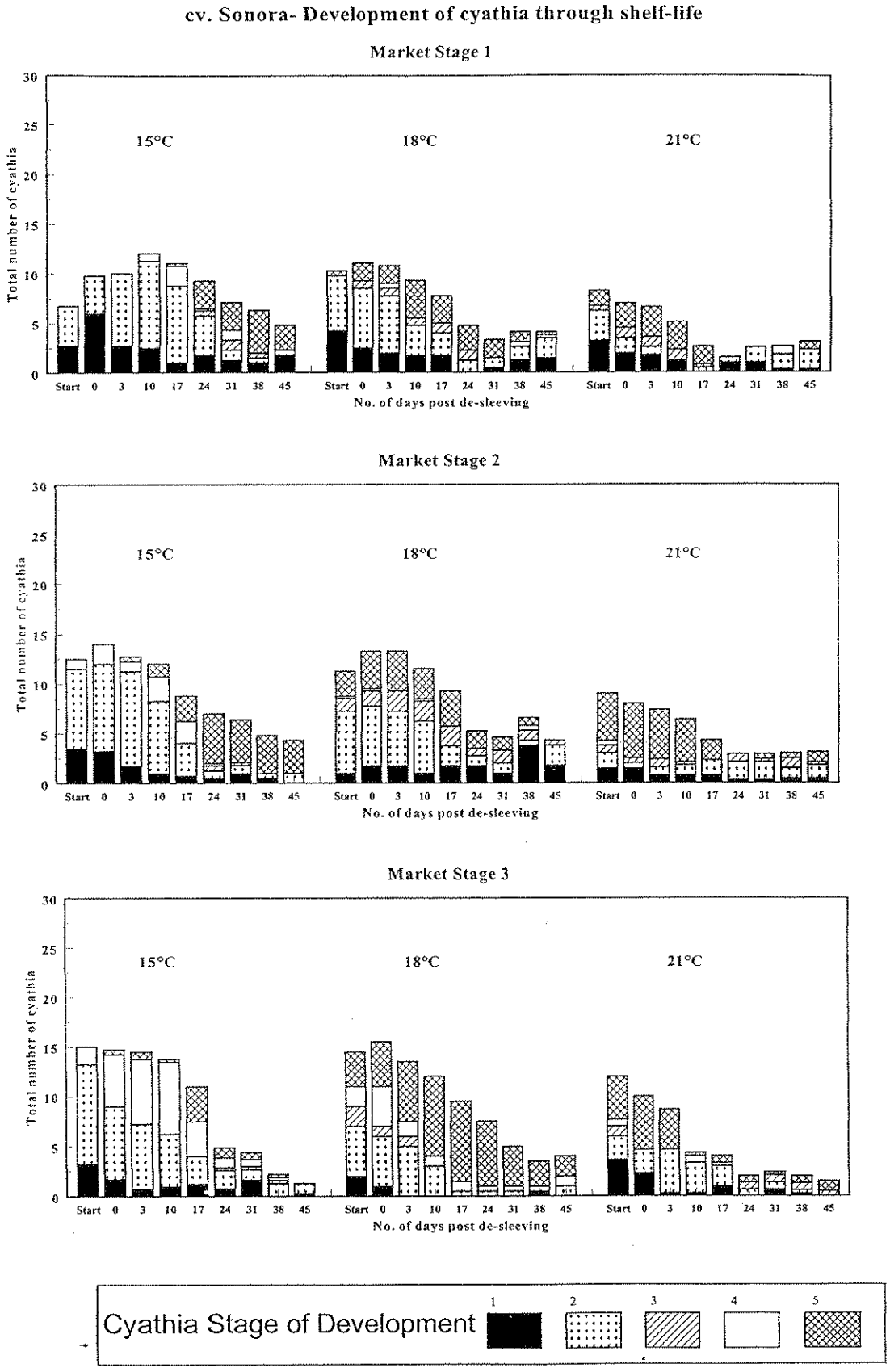


Appendix 5: Figure 4

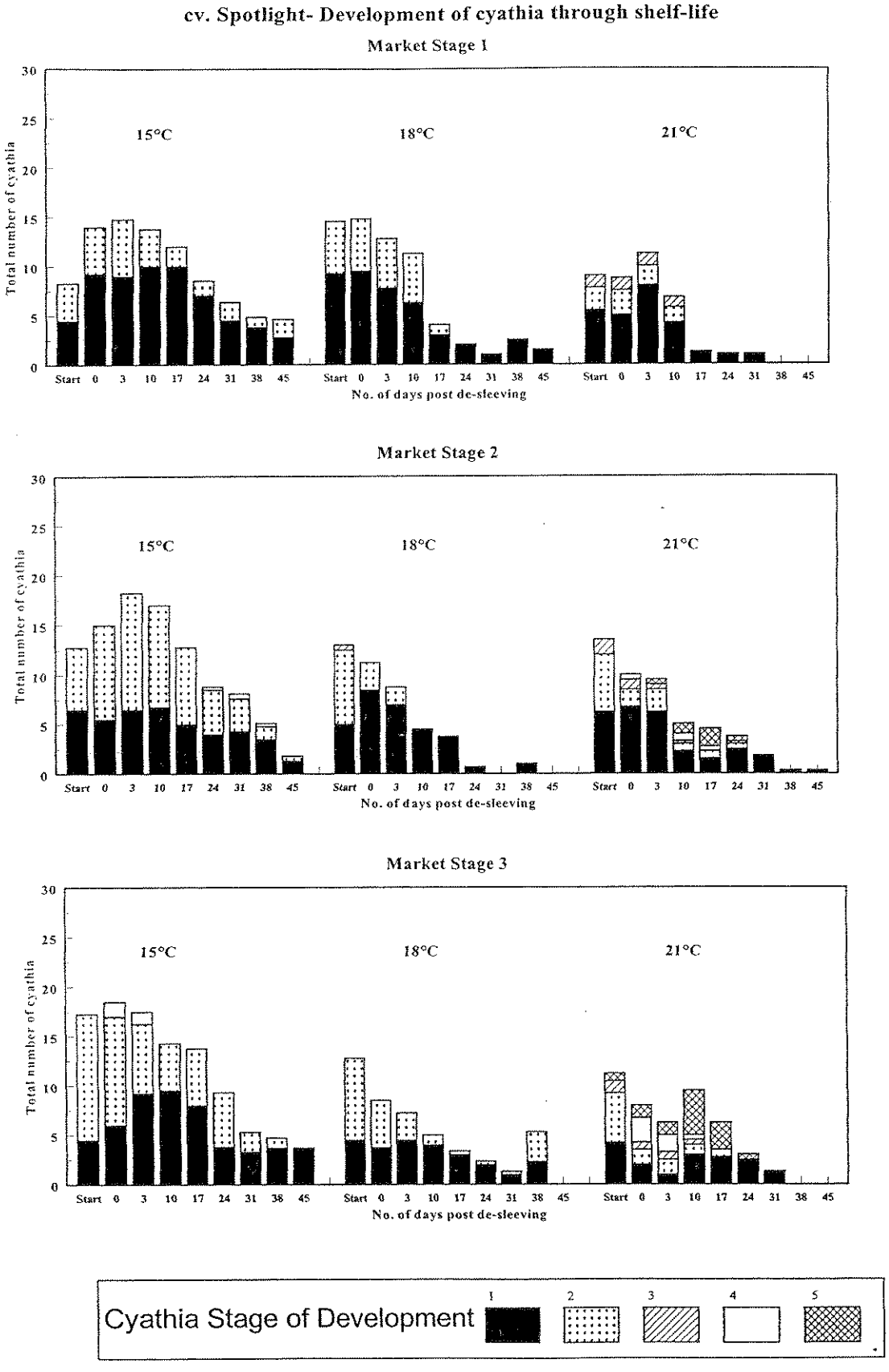
cv. Freedom



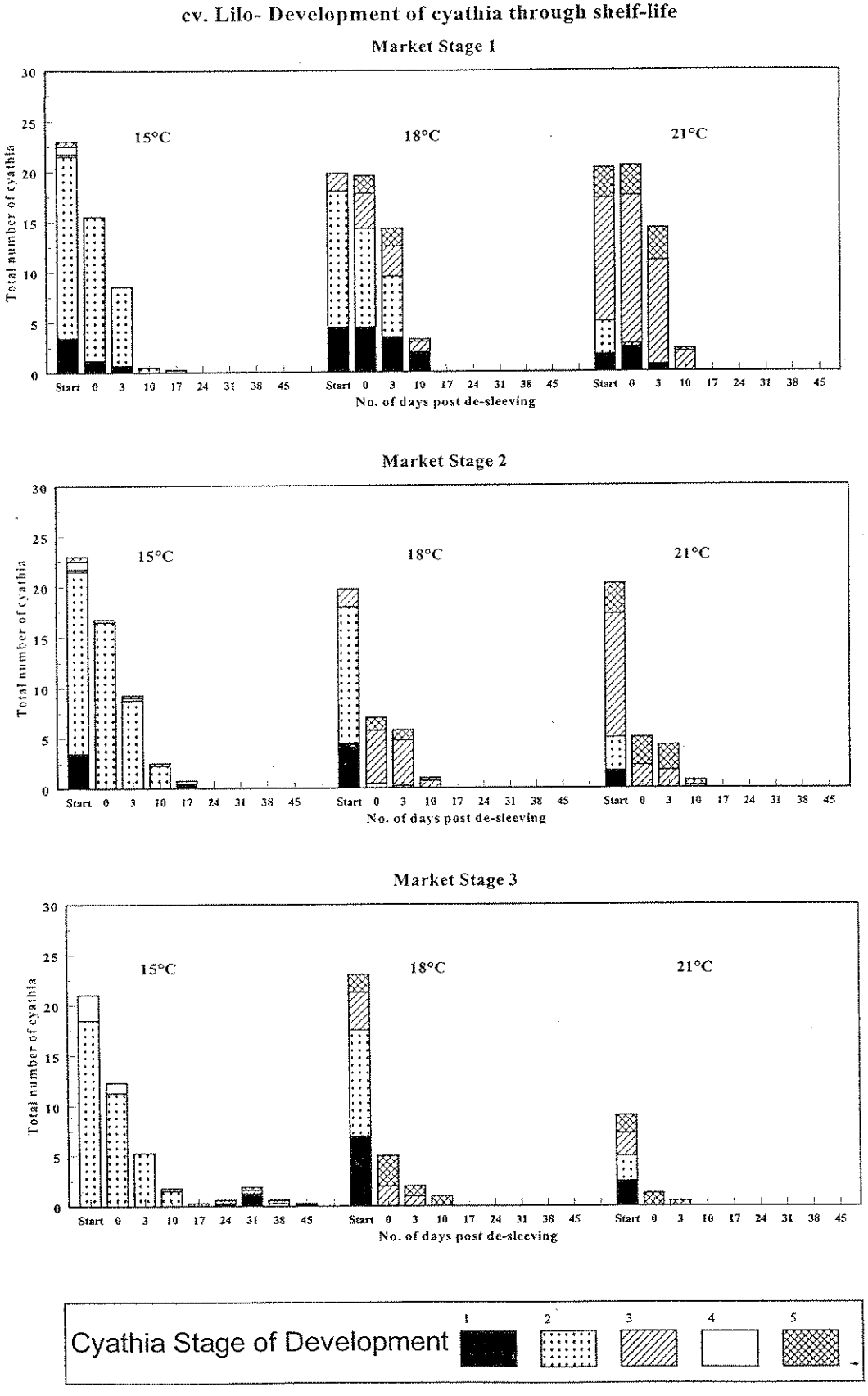
Appendix 5: Figure 5



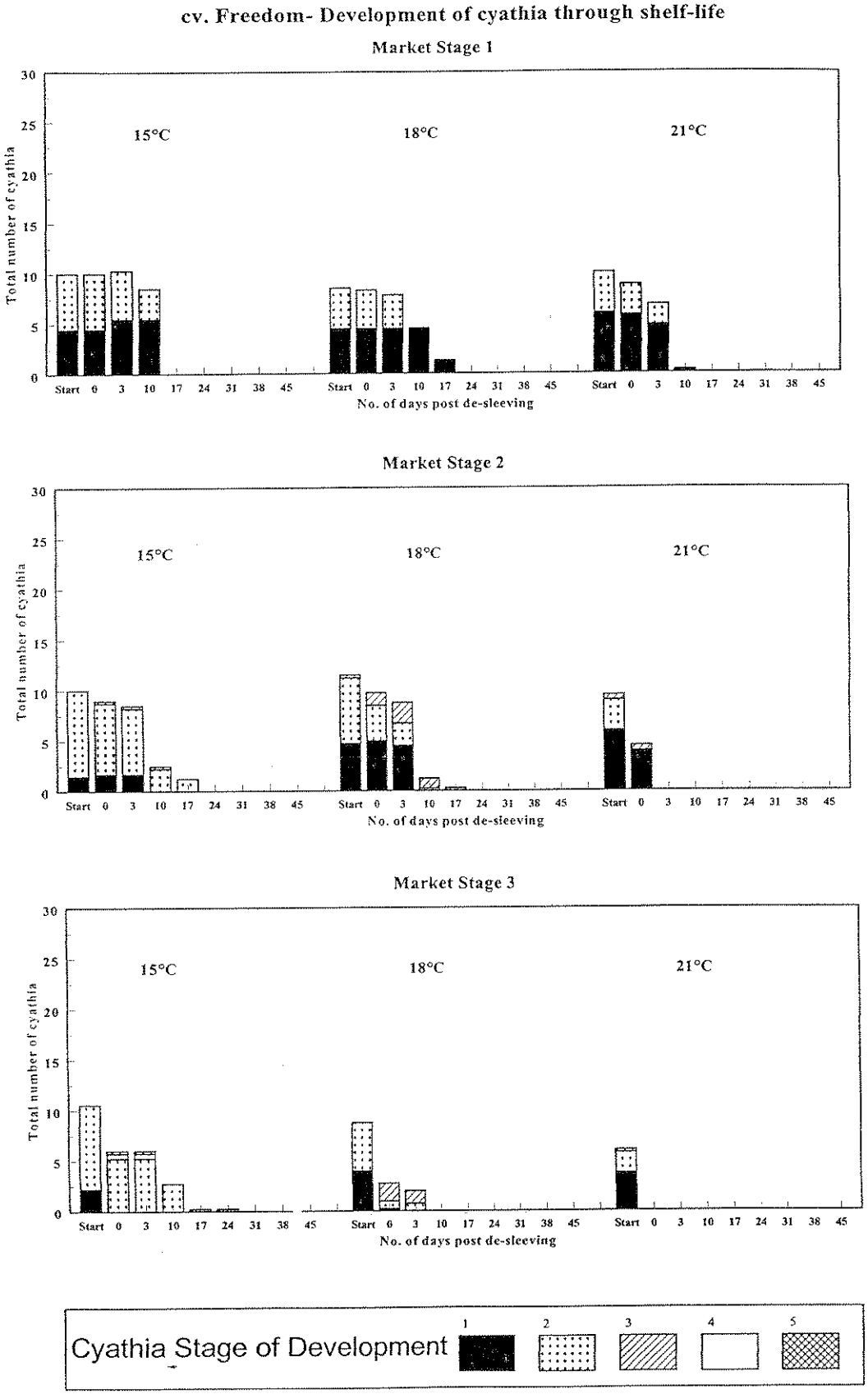
Appendix 5: Figure 6



Appendix 5: Figure 7



Appendix 5: Figure 8

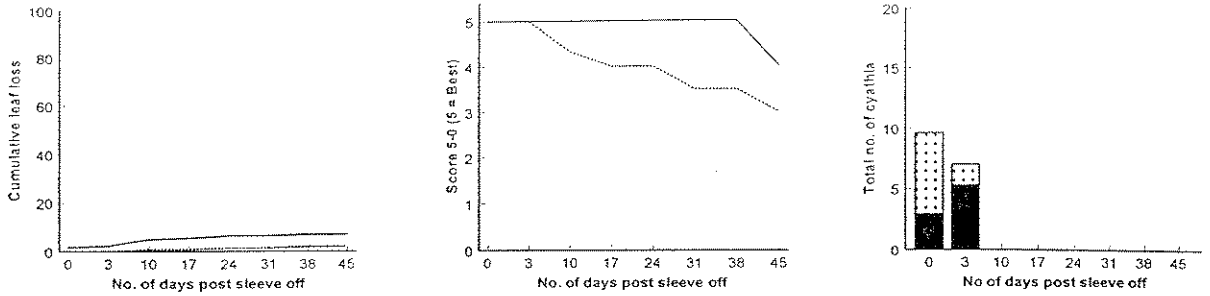


APPENDIX 6 : Shelf-life data: New Varieties

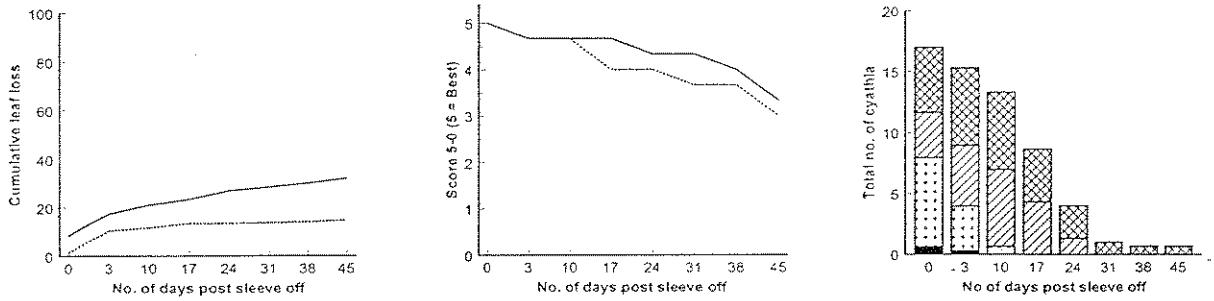
Appendix 6: Figure 1

cv. Lilo

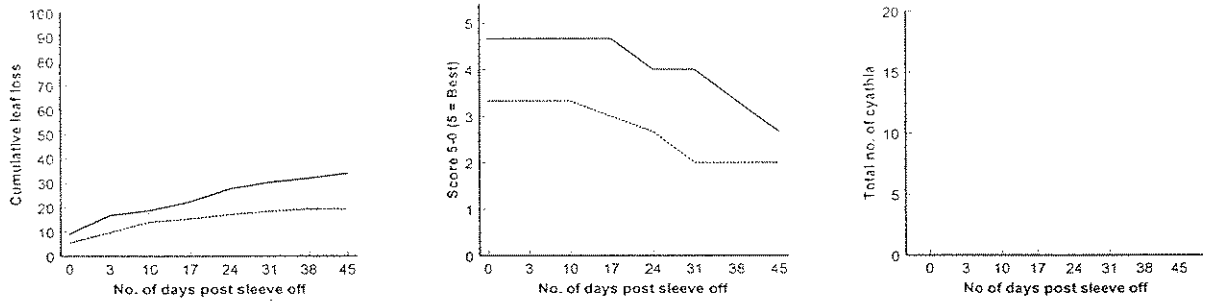
Grower 1



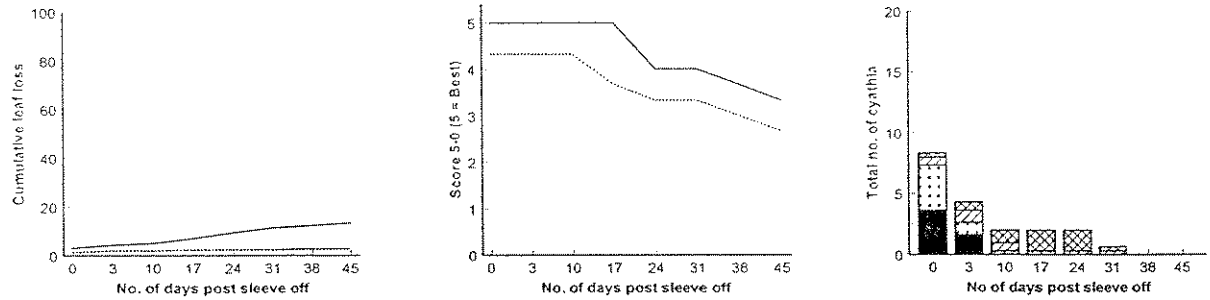
Grower 2

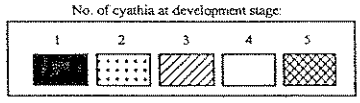


Grower 3



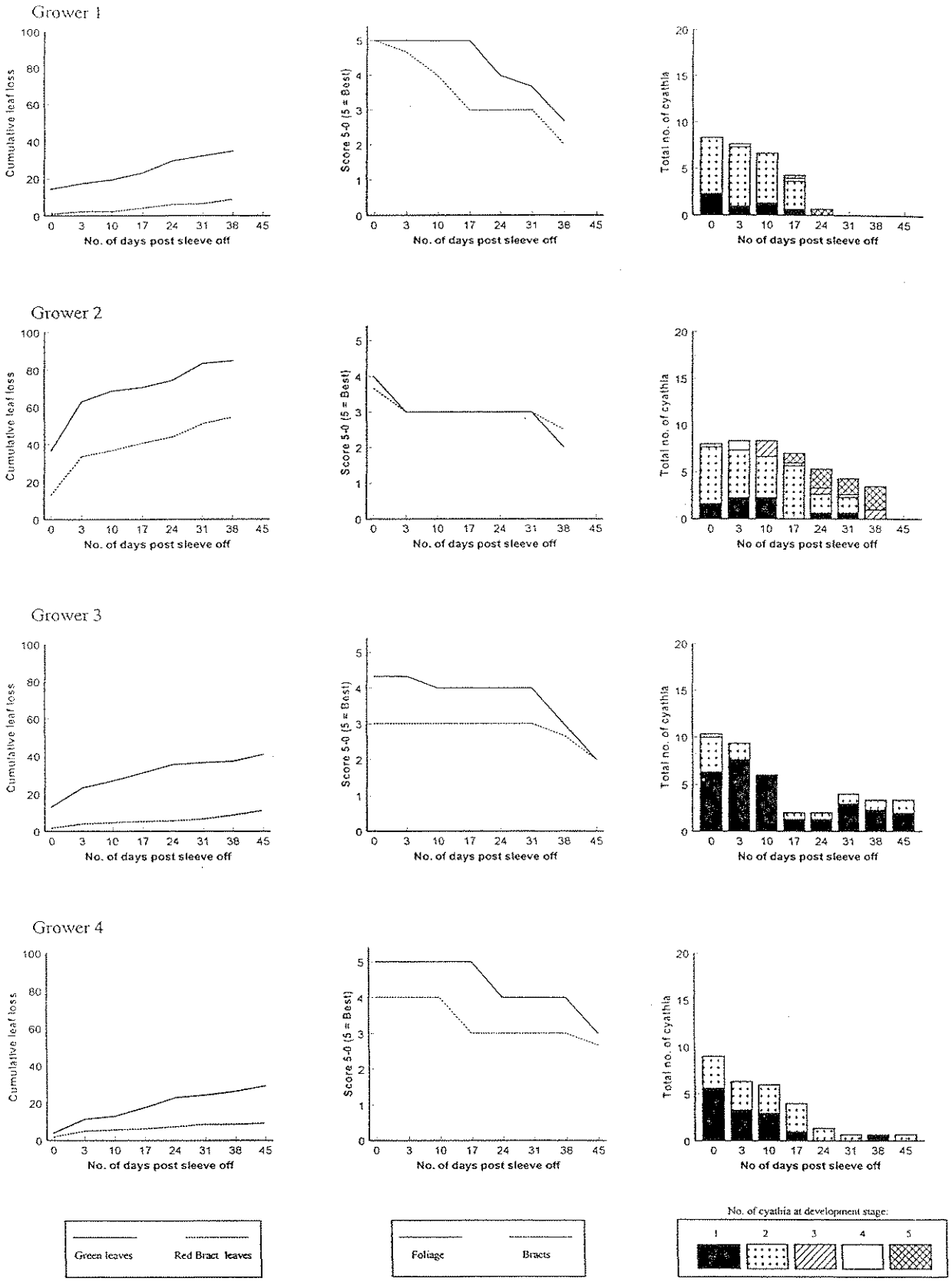
Grower 4





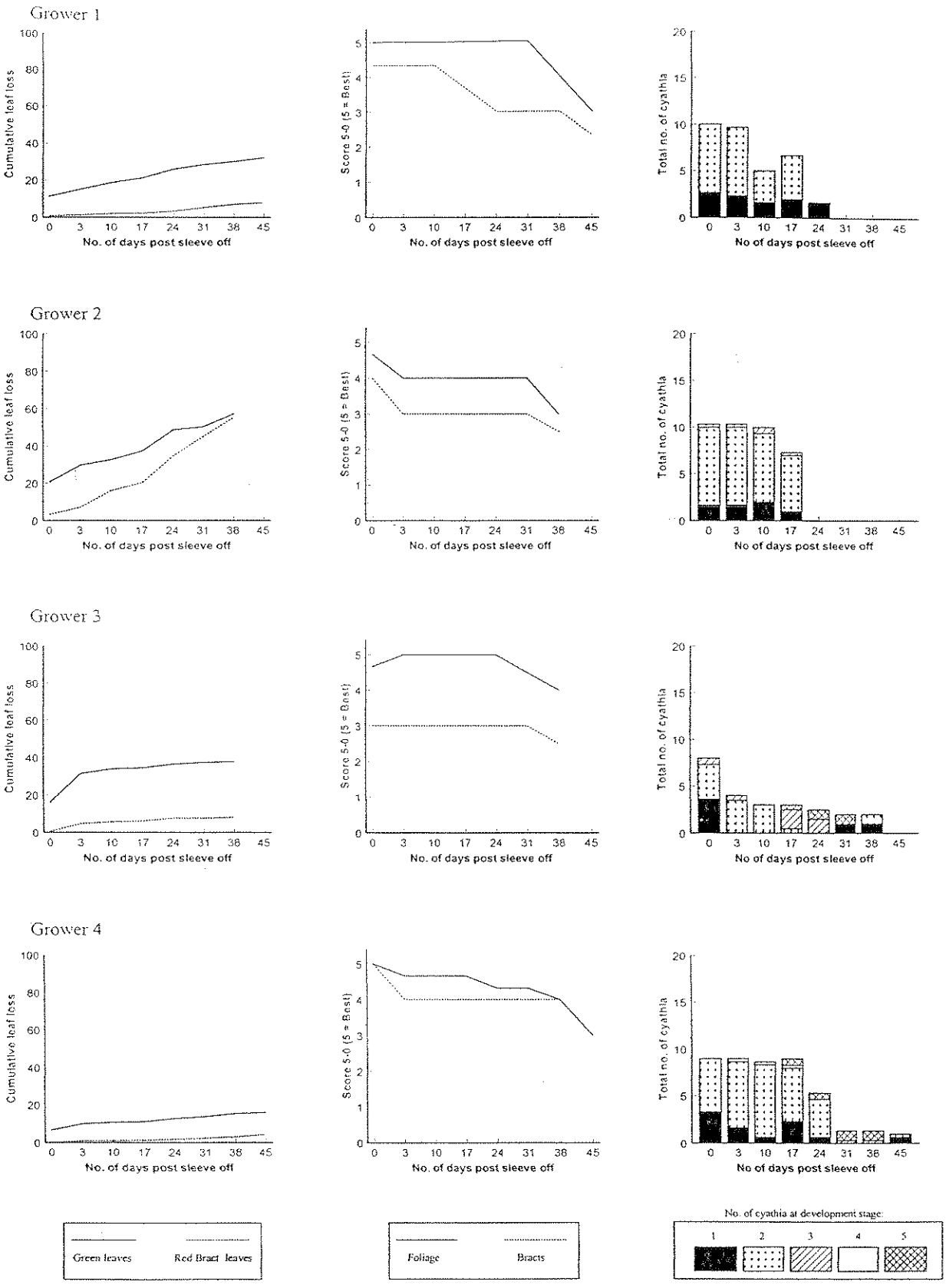
Appendix 6: Figure 2

cv. Sonora (Yoder)



Appendix 6: Figure 3

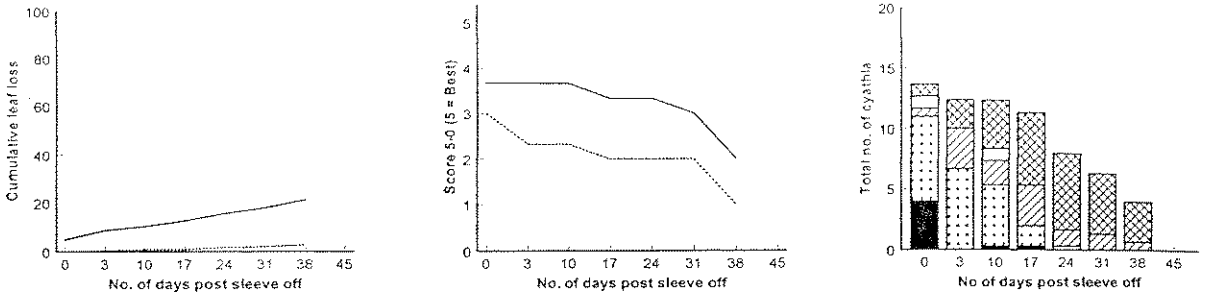
cv. Sonora (Selecta)



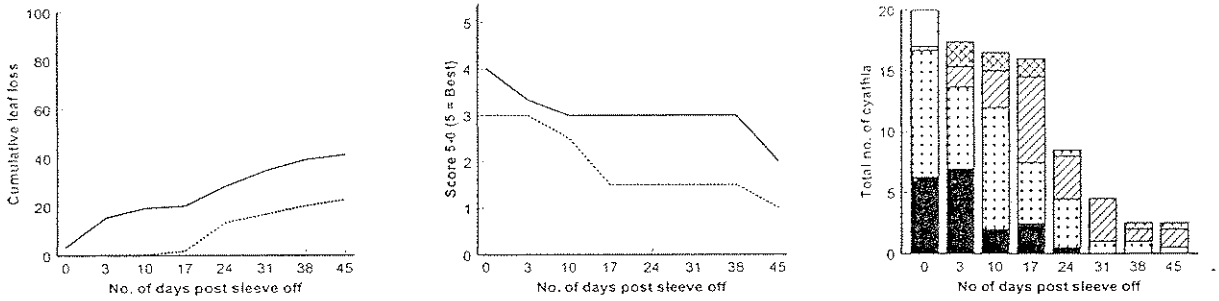
Appendix 6: Figure 4

cv. Santa Claus

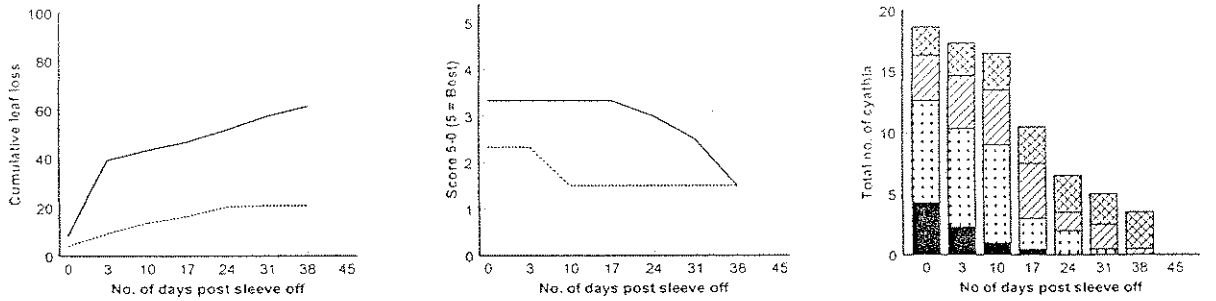
Grower 1



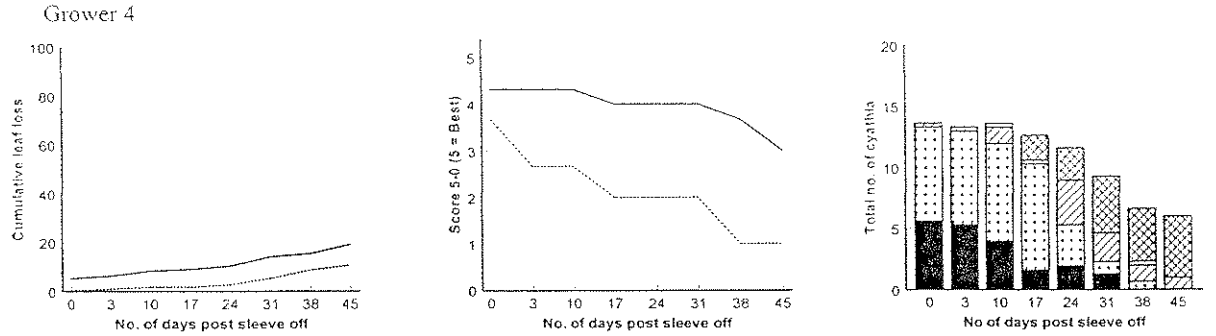
Grower 2



Grower 3



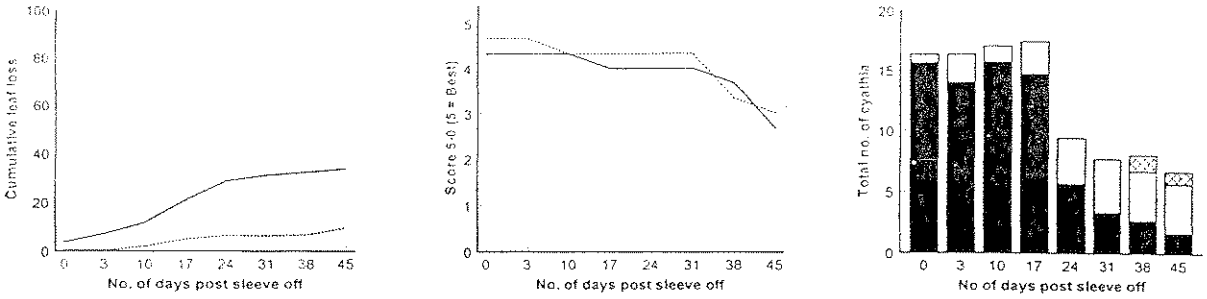
Grower 4



Appendix 6: Figure 5

cv. White Christmas

Grower 1



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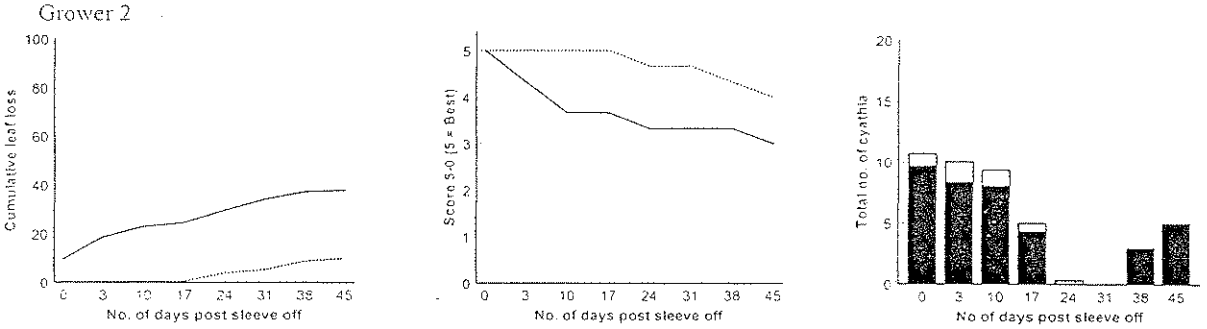
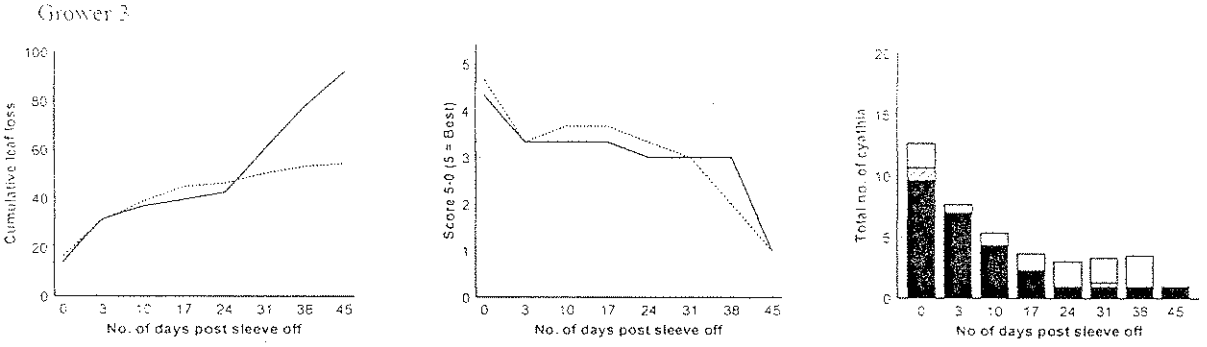
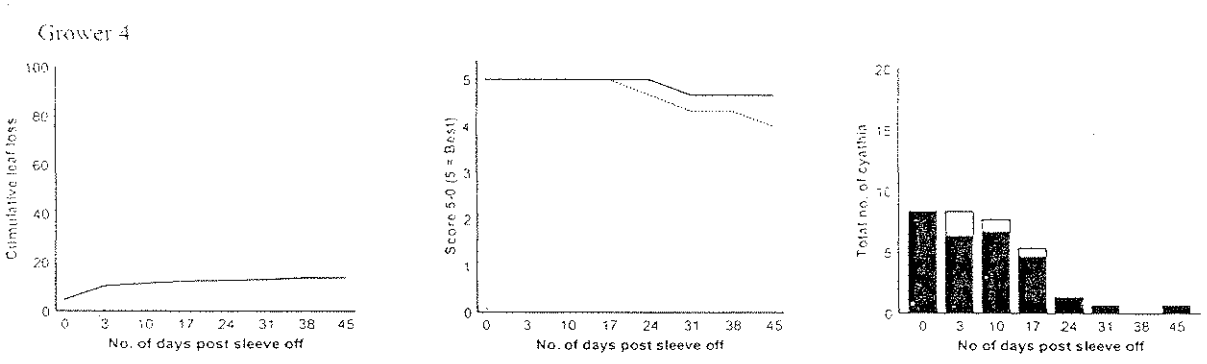


Grower 3



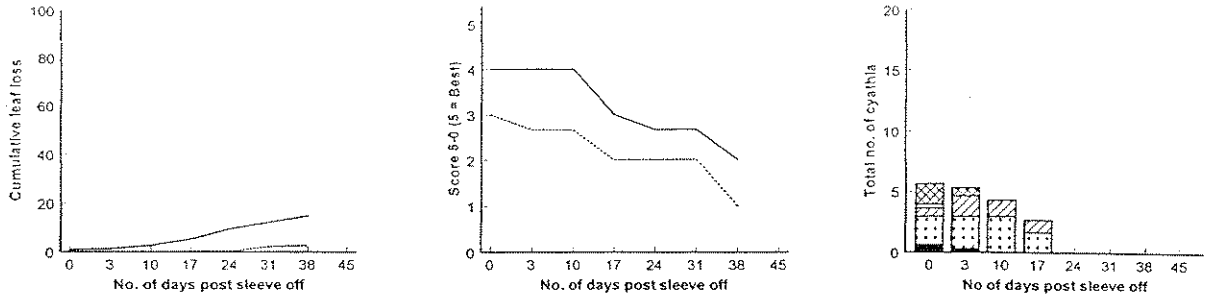
Grower 4



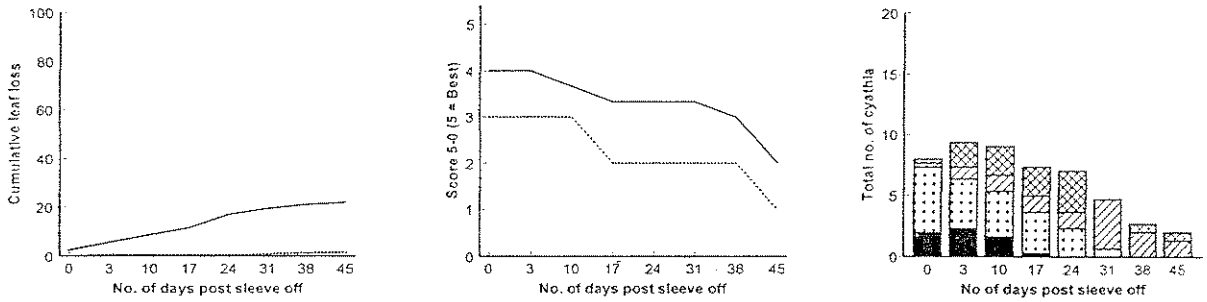
Appendix 6: Figure 6

cv. Christmas Carol

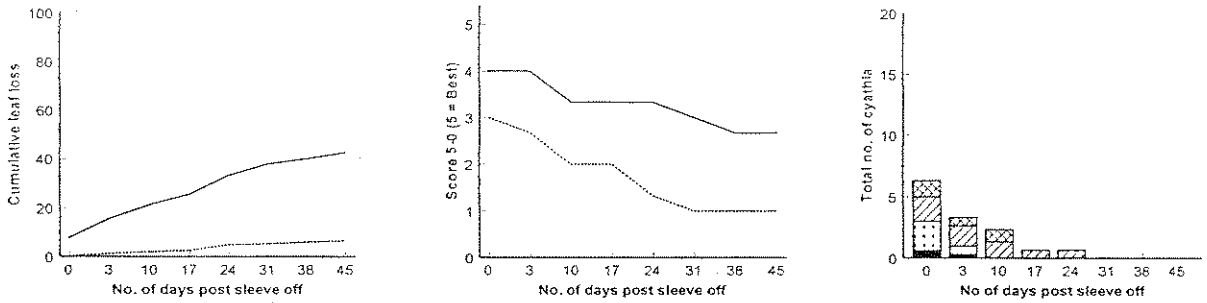
Grower 1



Grower 2



Grower 3



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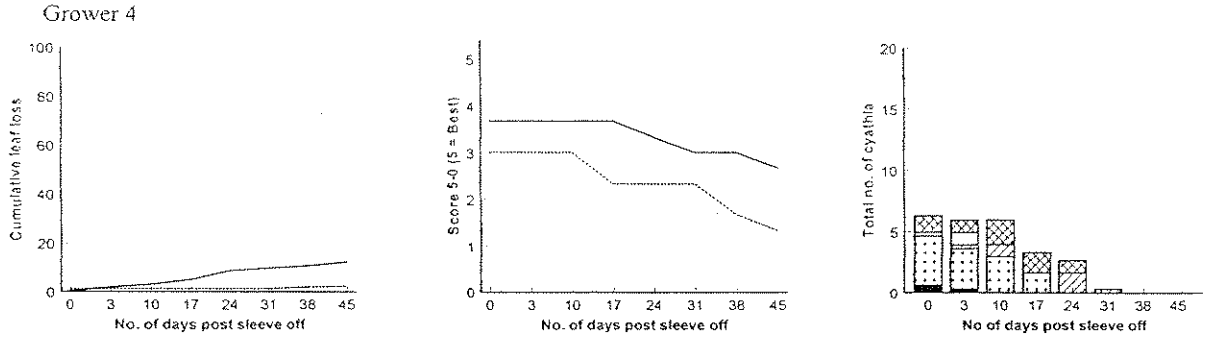
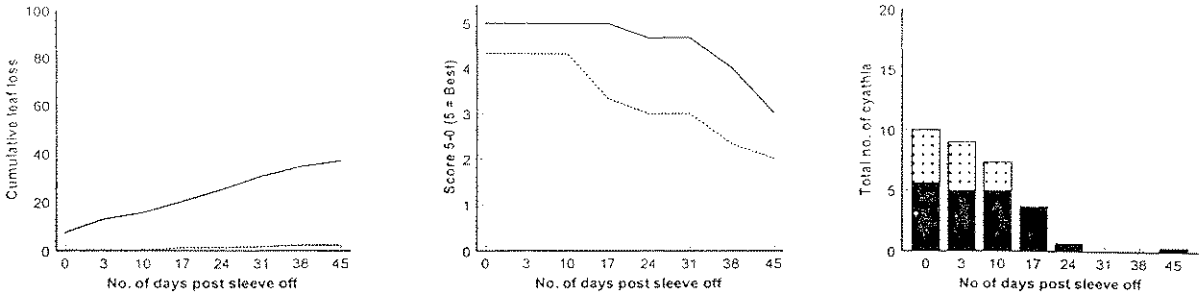


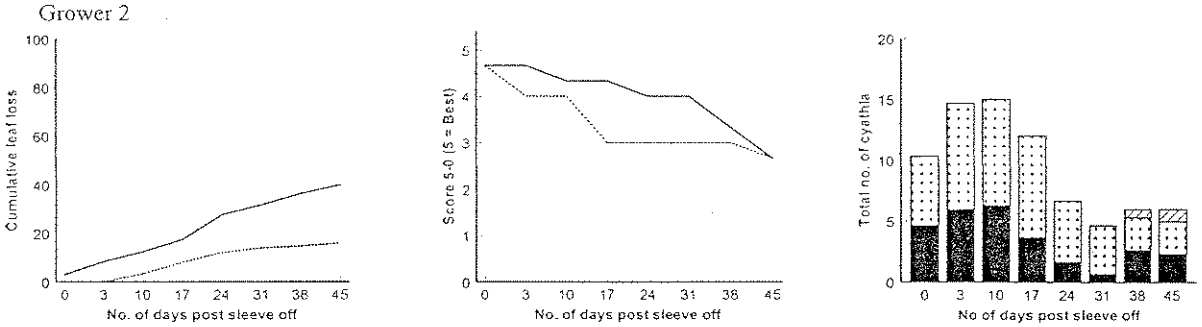
Appendix 6: Figure 7

cv. Xenia

Grower 1



Grower 2



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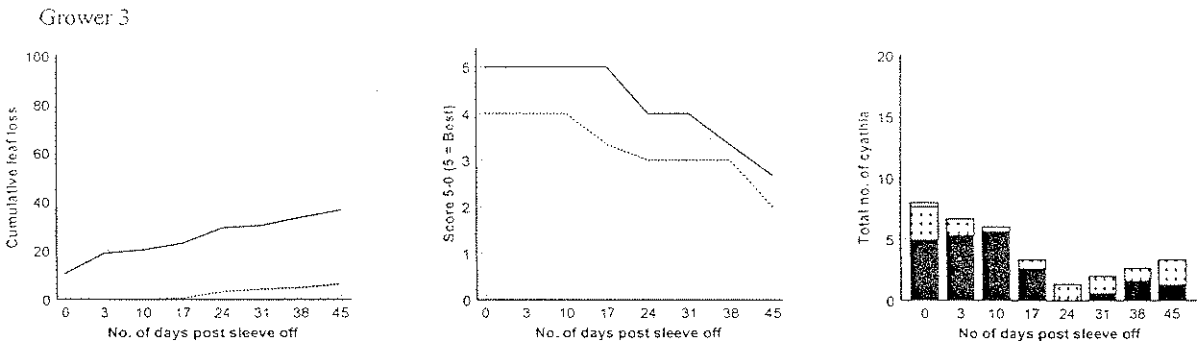
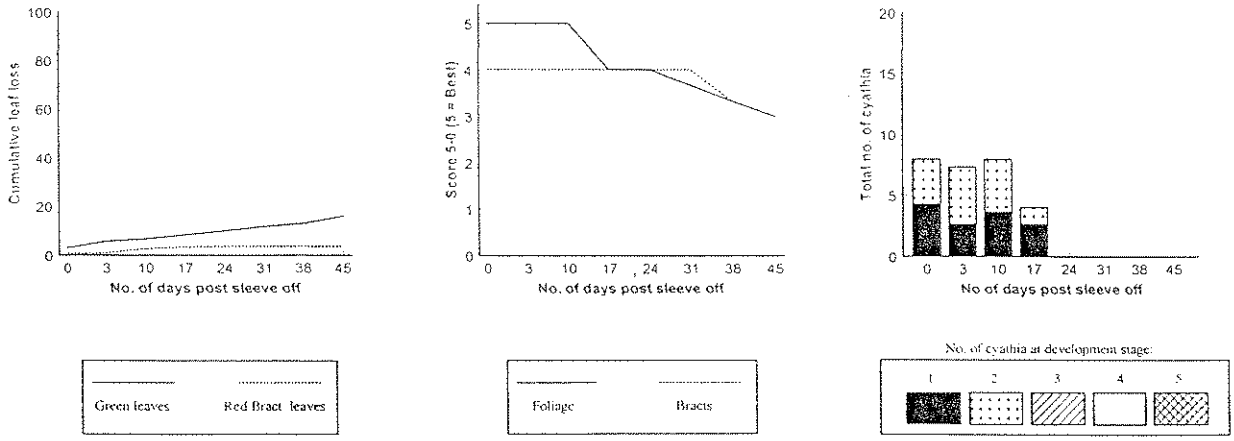


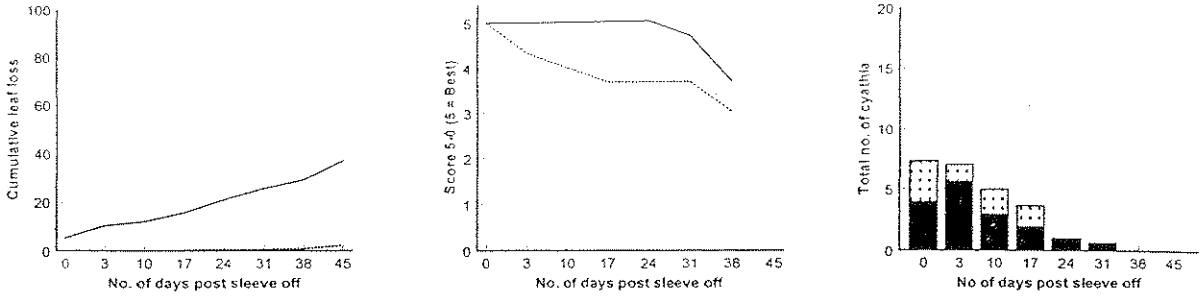
Grower 4



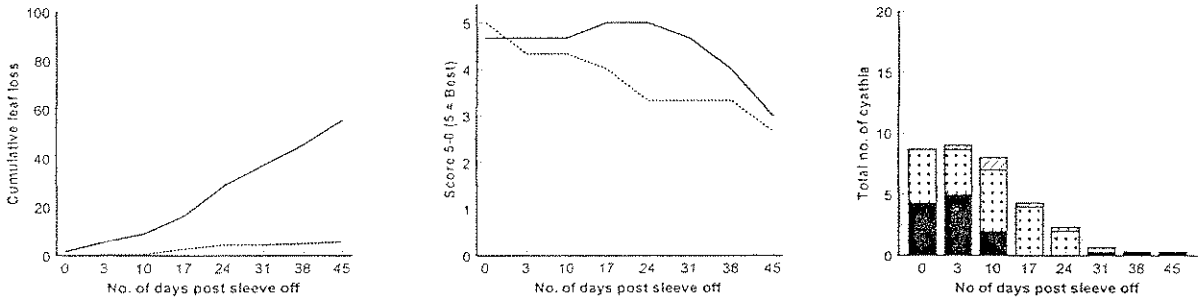
Appendix 6: Figure 8

cv. Malibu

Grower 1



Grower 2



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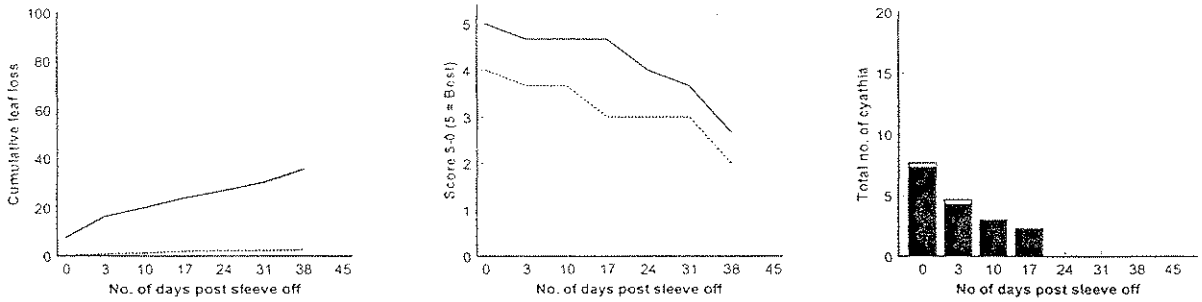

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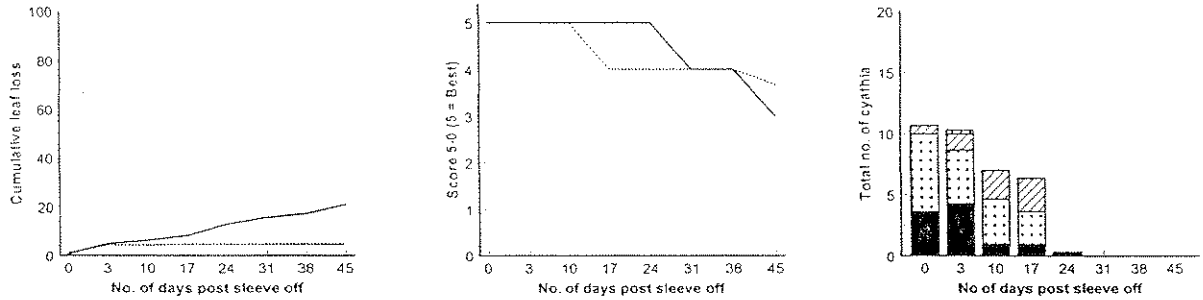
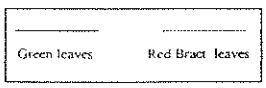
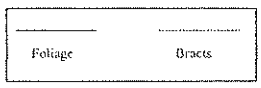
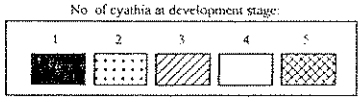




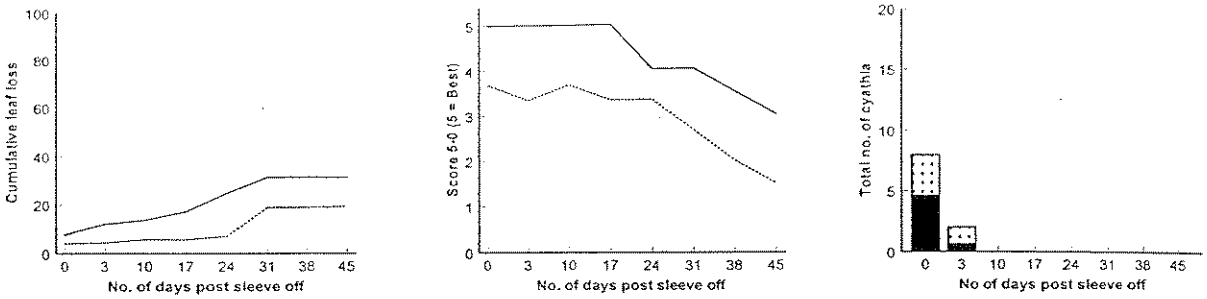




Appendix 6: Figure 9

cv. Coco Red

Grower 1



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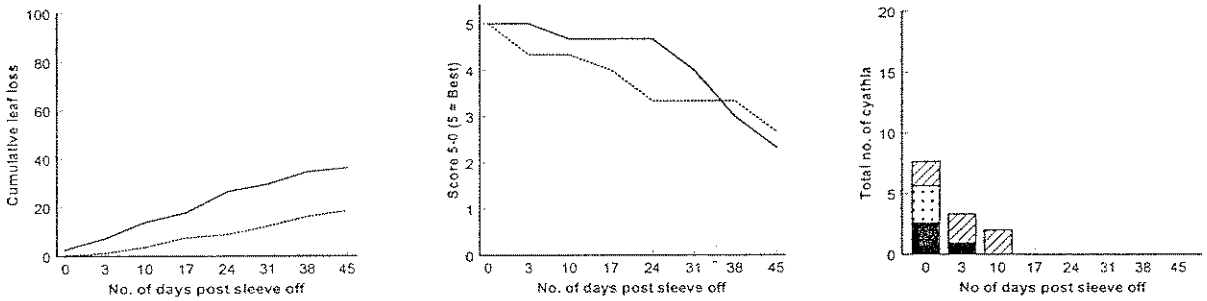
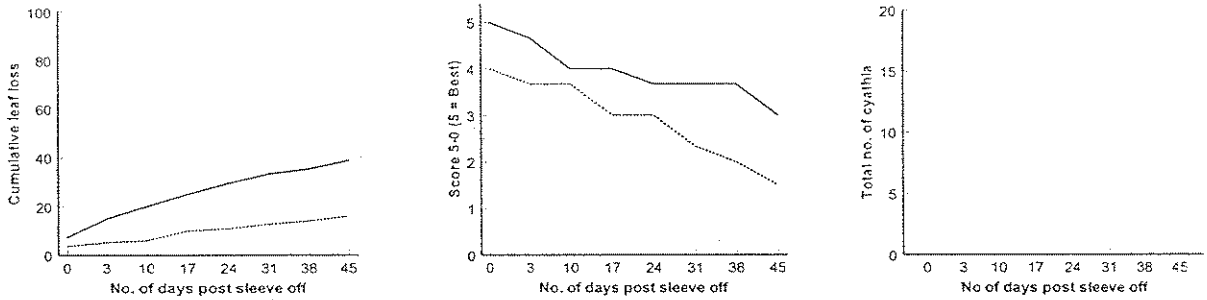
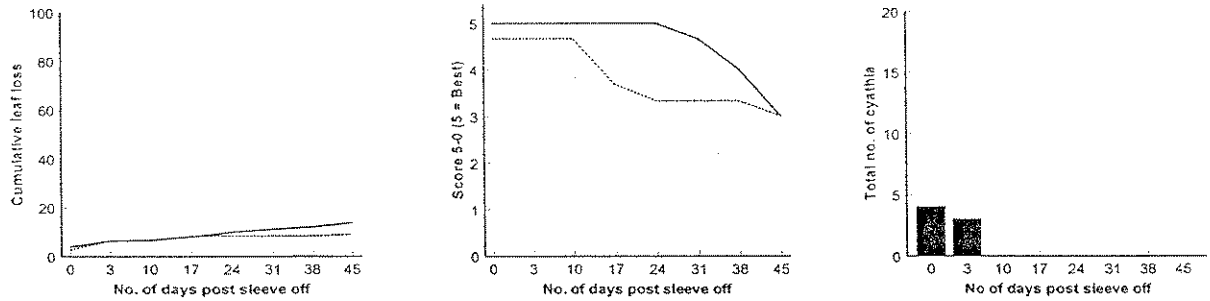
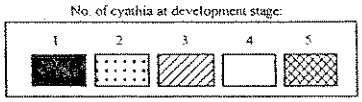


Grower 3



Grower 4

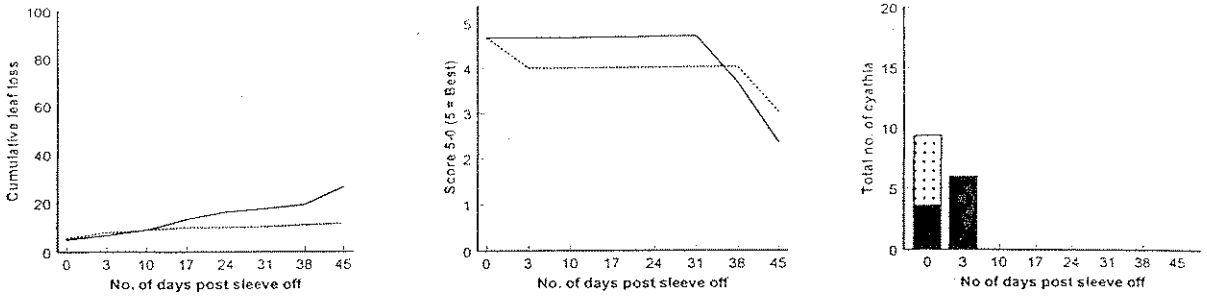




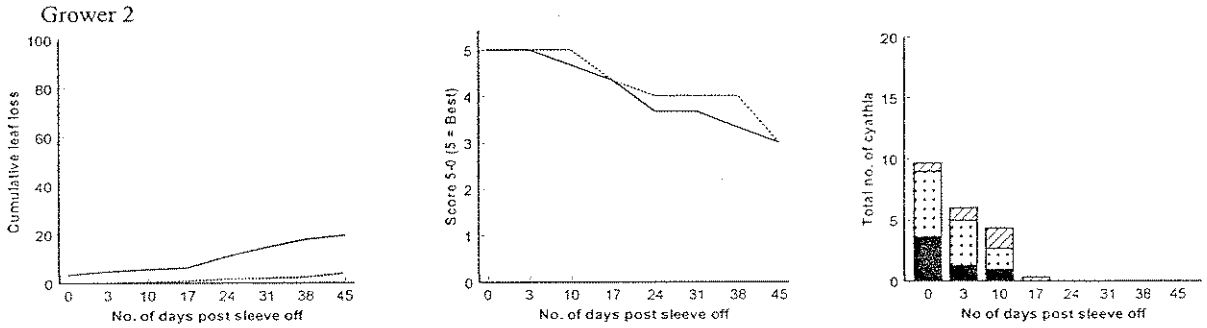
Appendix 6: Figure 10

cv. 2969

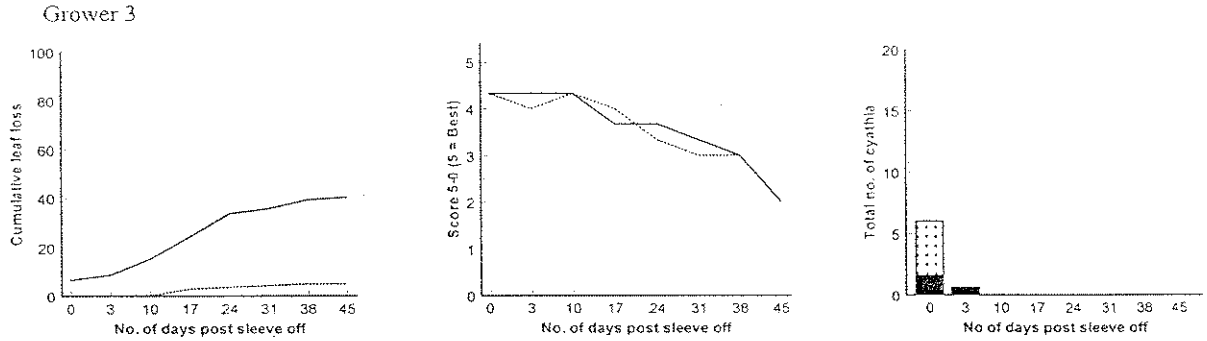
Grower 1



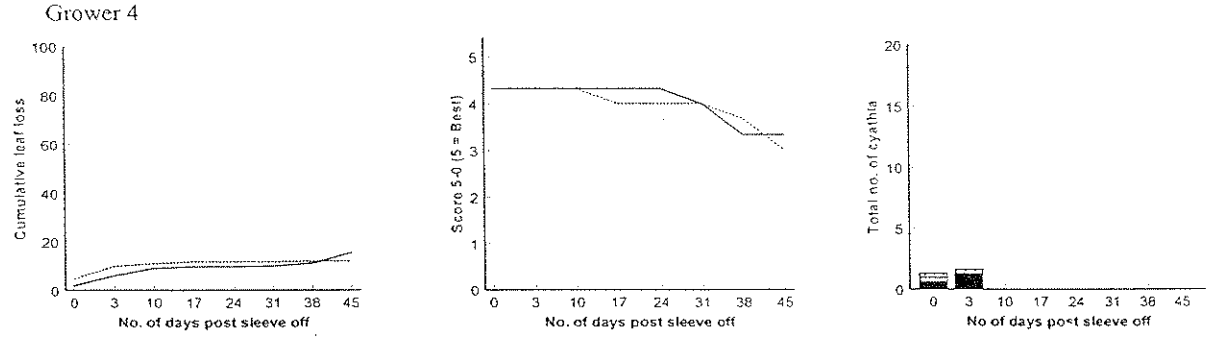
Grower 2

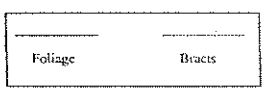


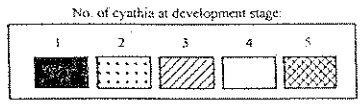
Grower 3



Grower 4



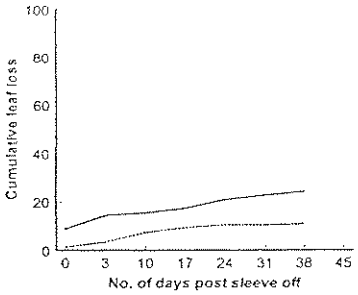


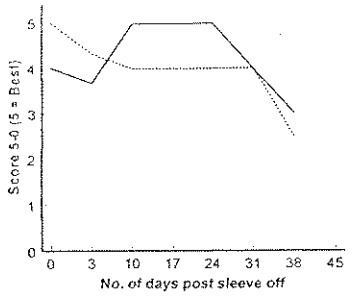


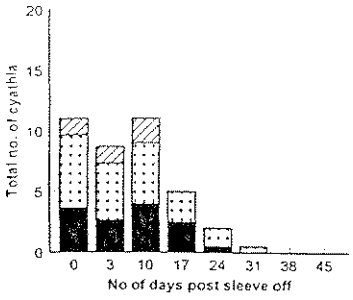
Appendix 6: Figure 11

cv. 457

Grower 1







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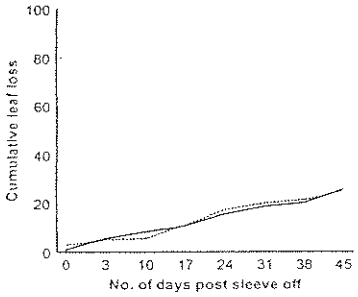

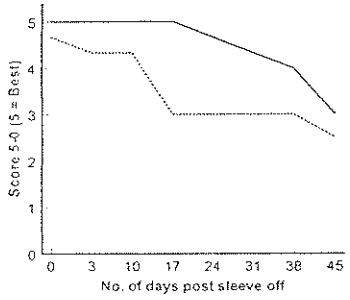

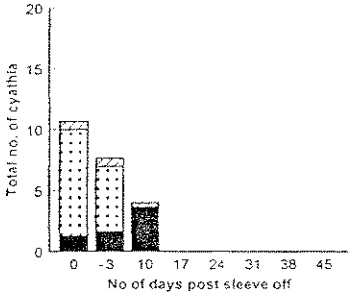

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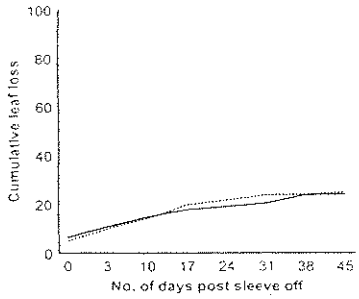
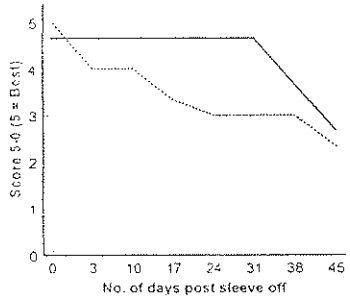
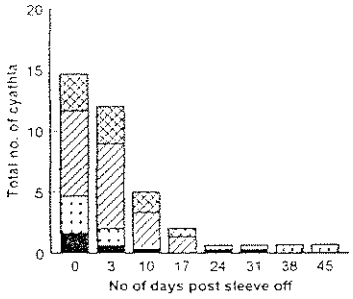
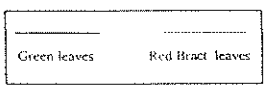
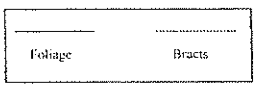
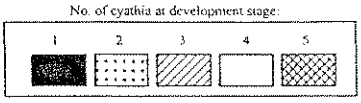








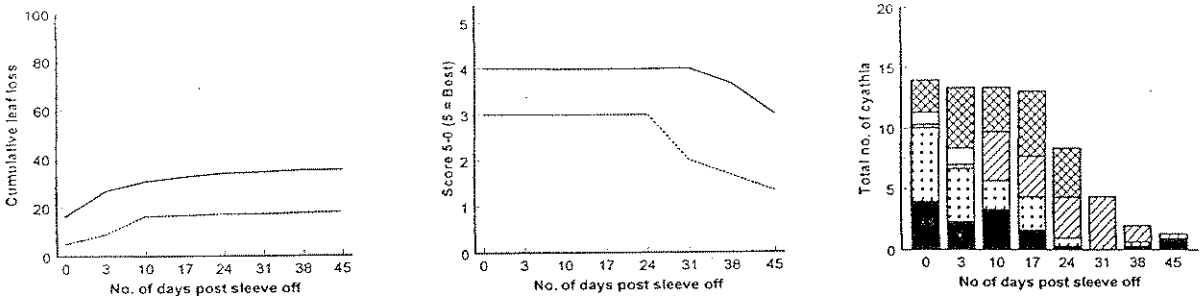




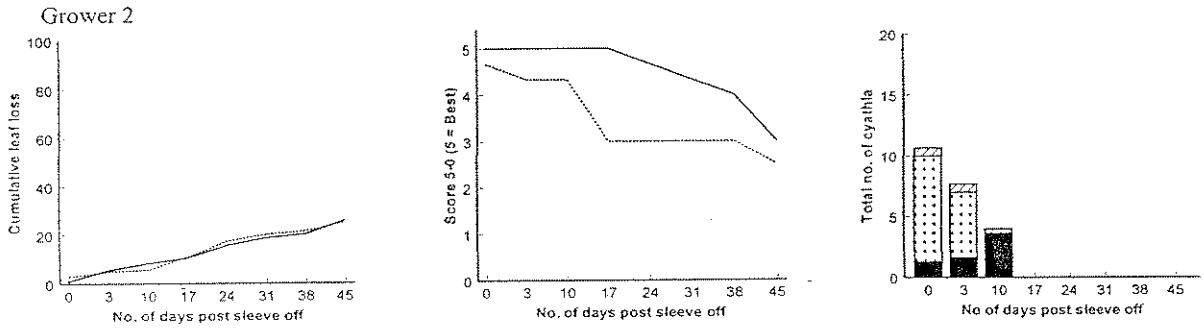
Appendix 6: Figure 12

cv. Tabaluga

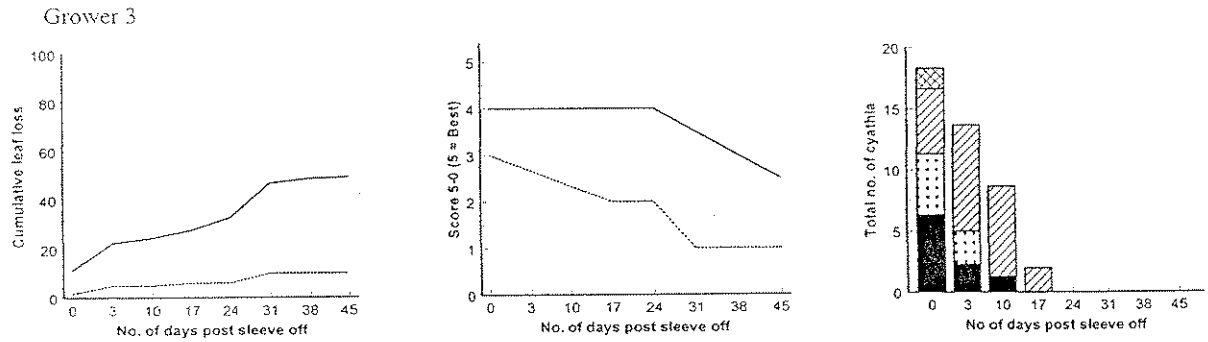
Grower 1



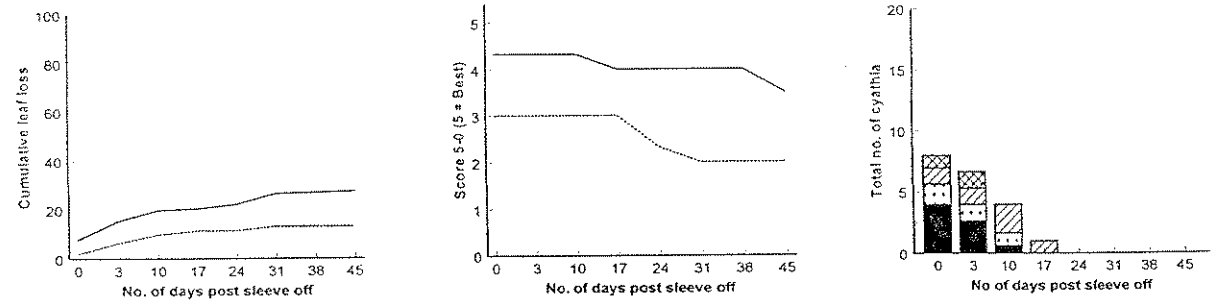
Grower 2

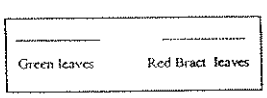


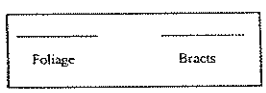
Grower 3

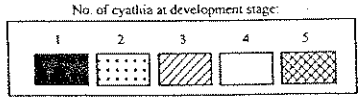


Grower 4



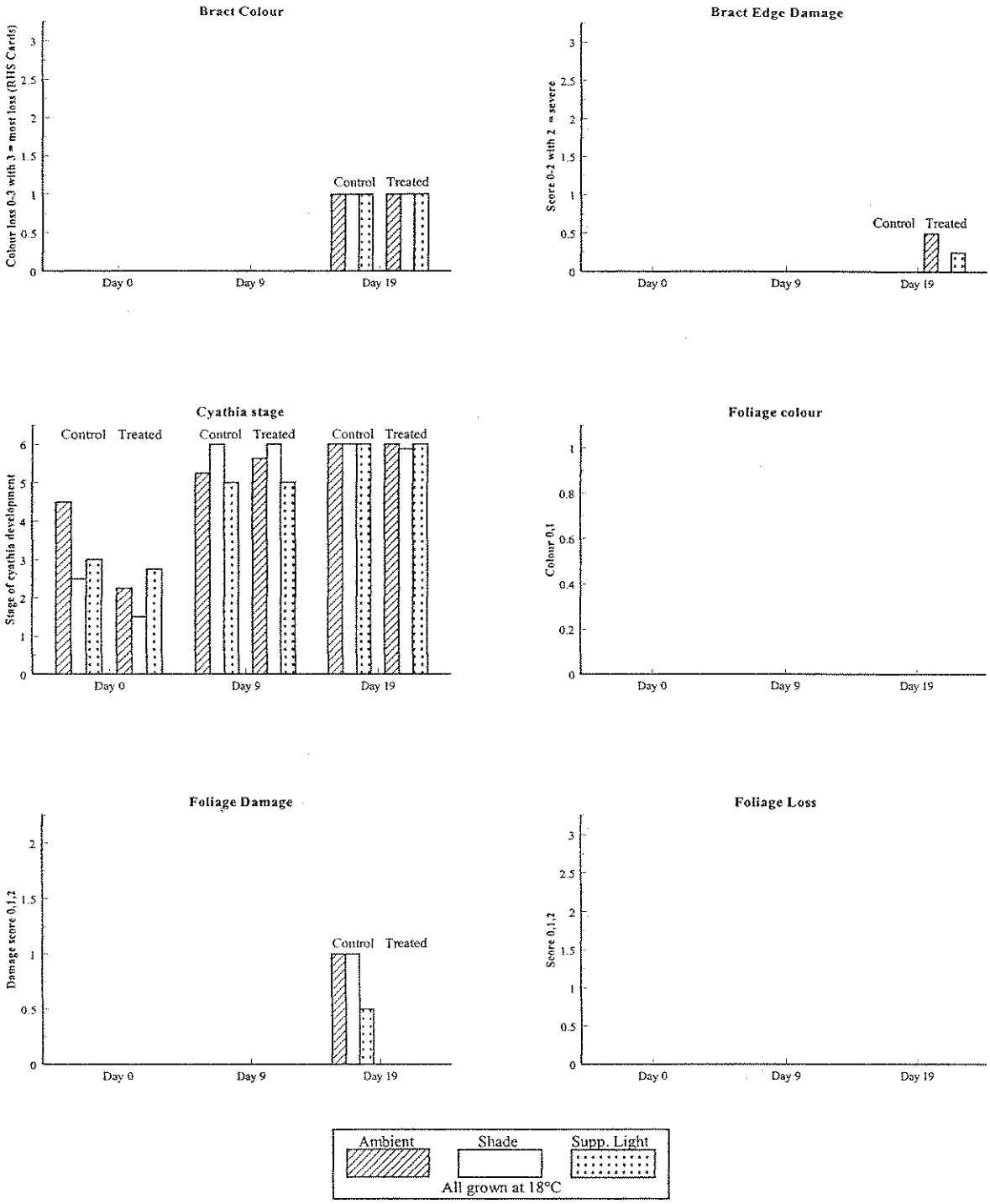






APPENDIX 7 :
Propoxur smoke trial data

Appendix 7: Figure 1 cv. Lilo

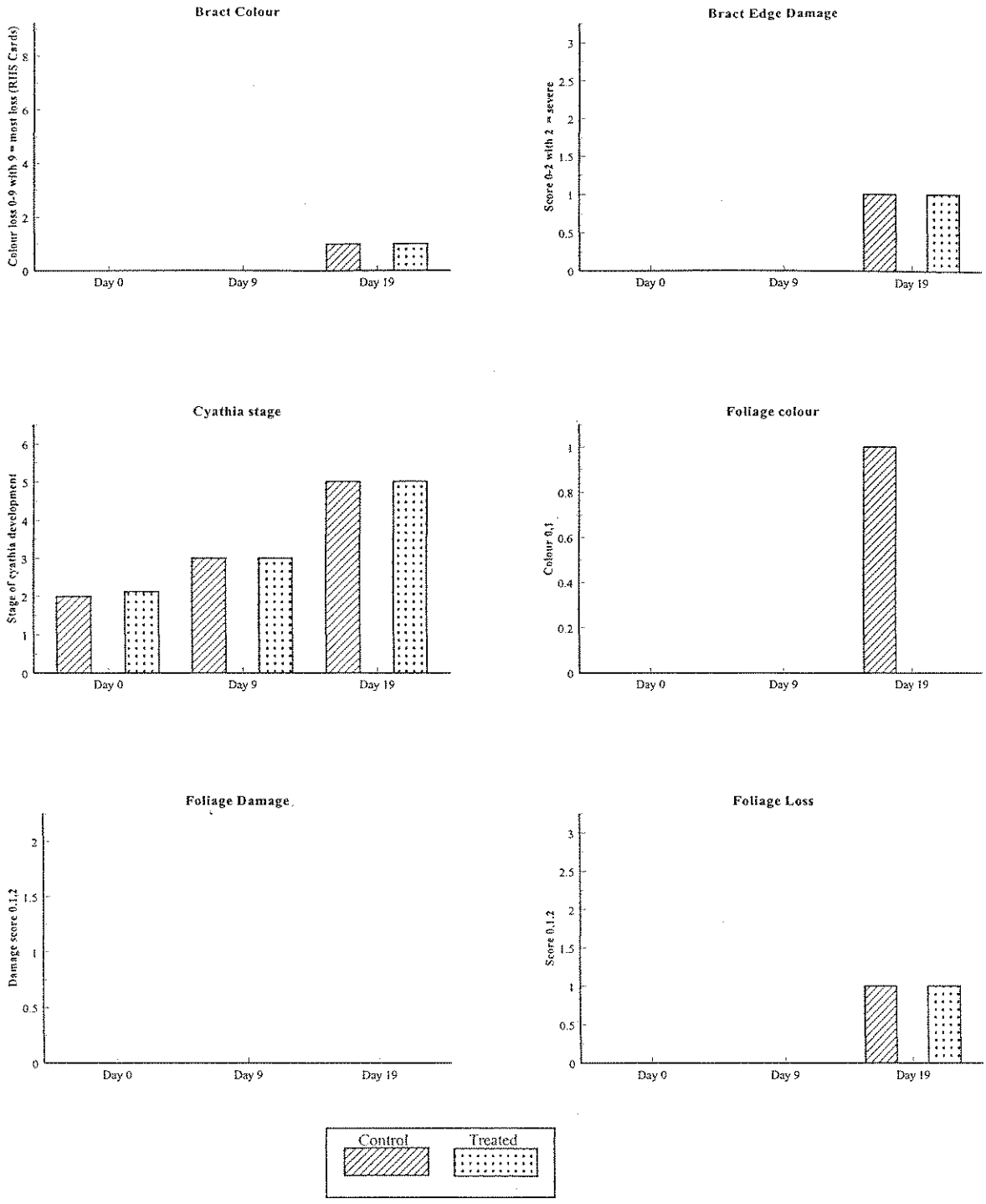


Note:

Bract Edge Damage	1=None, 2=Moderate, 3=Severe
Cyathia Stage	1=Green, 2=Colour, 3=Pollen, 4=Stigma, 5=Pollen & Stigma, 6=Aborted
Foliage Colour	0=Uniform, 1=Patchy
Foliage Damage	0=None, 1=Moderate, 2=Severe
Foliage Loss	1=None, 2=Moderate, 3=Severe

Appendix 7: Figure 2

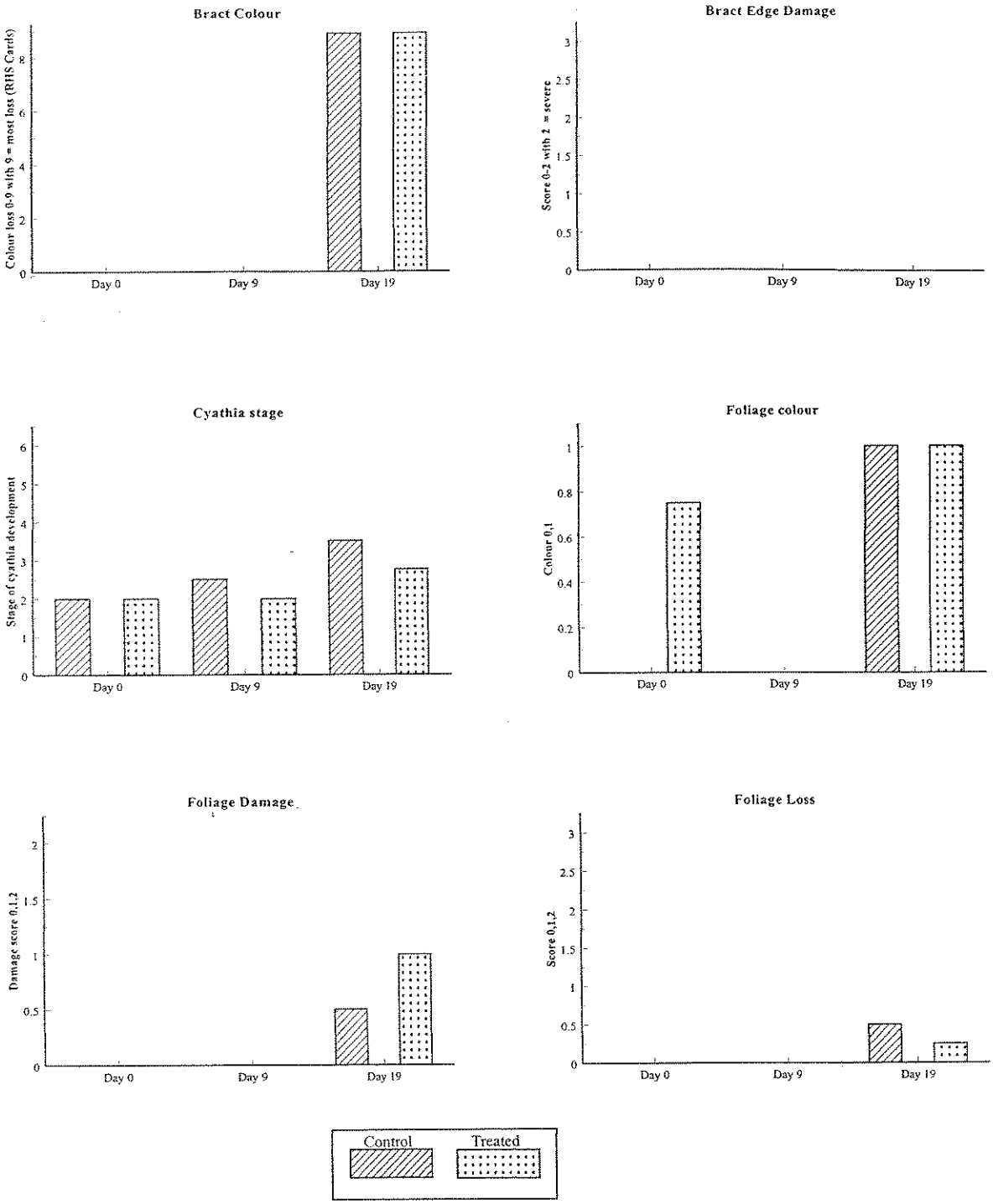
cv. Tabaluga



Note:

Bract Edge Damage	1=None, 2=Moderate, 3=Severe
Cyathia Stage	1=Green, 2=Colour, 3=Pollen, 4=Stigma, 5=Pollen & Stigma, 6=Aborted
Foliage Colour	0=Uniform, 1=Patchy
Foliage Damage	0=None, 1=Moderate, 2=Severe
Foliage Loss	1=None, 2=Moderate, 3=Severe

Appendix 7: Figure 3 cv. White Christmas



Note:

Bract Edge Damage	1=None, 2=Moderate, 3=Severe
Cyathia Stage	1=Green, 2=Colour, 3=Pollen, 4=Stigma, 5=Pollen & Stigma, 6=Aborted
Foliage Colour	0=Uniform, 1=Patchy
Foliage Damage	0=None, 1=Moderate, 2=Severe
Foliage Loss	1=None, 2=Moderate, 3=Severe

Plate 1: Stages of cyathia development showing unopened green bud (1), coloured bud (2), pollen showing (3), stigma open (4; not present without pollen showing), pollen showing & stigma open (5).

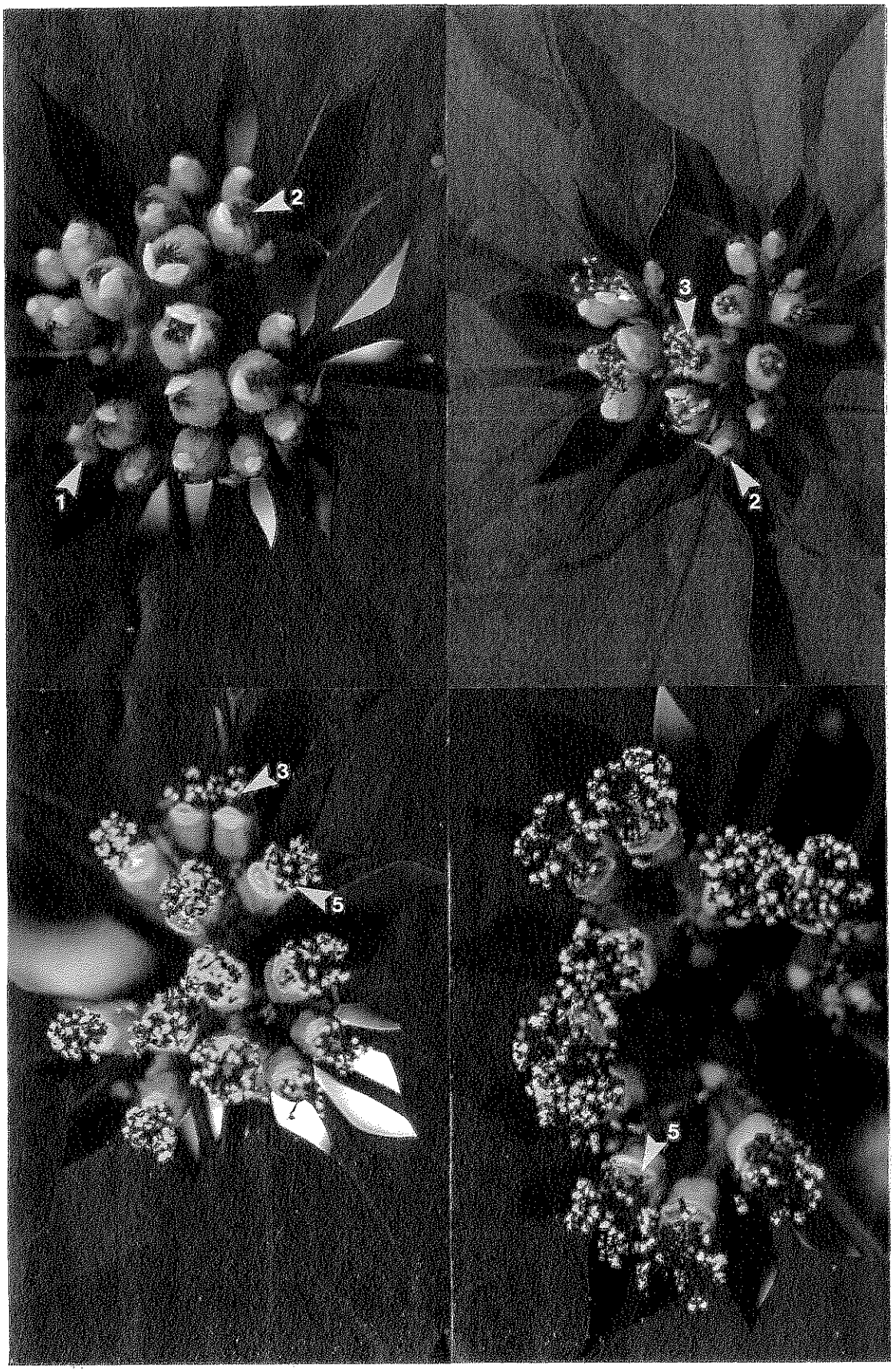


Plate 2: Effects of temperature applied from week 43 on Poinsettia "Sonora" grown in three different lighting environments.

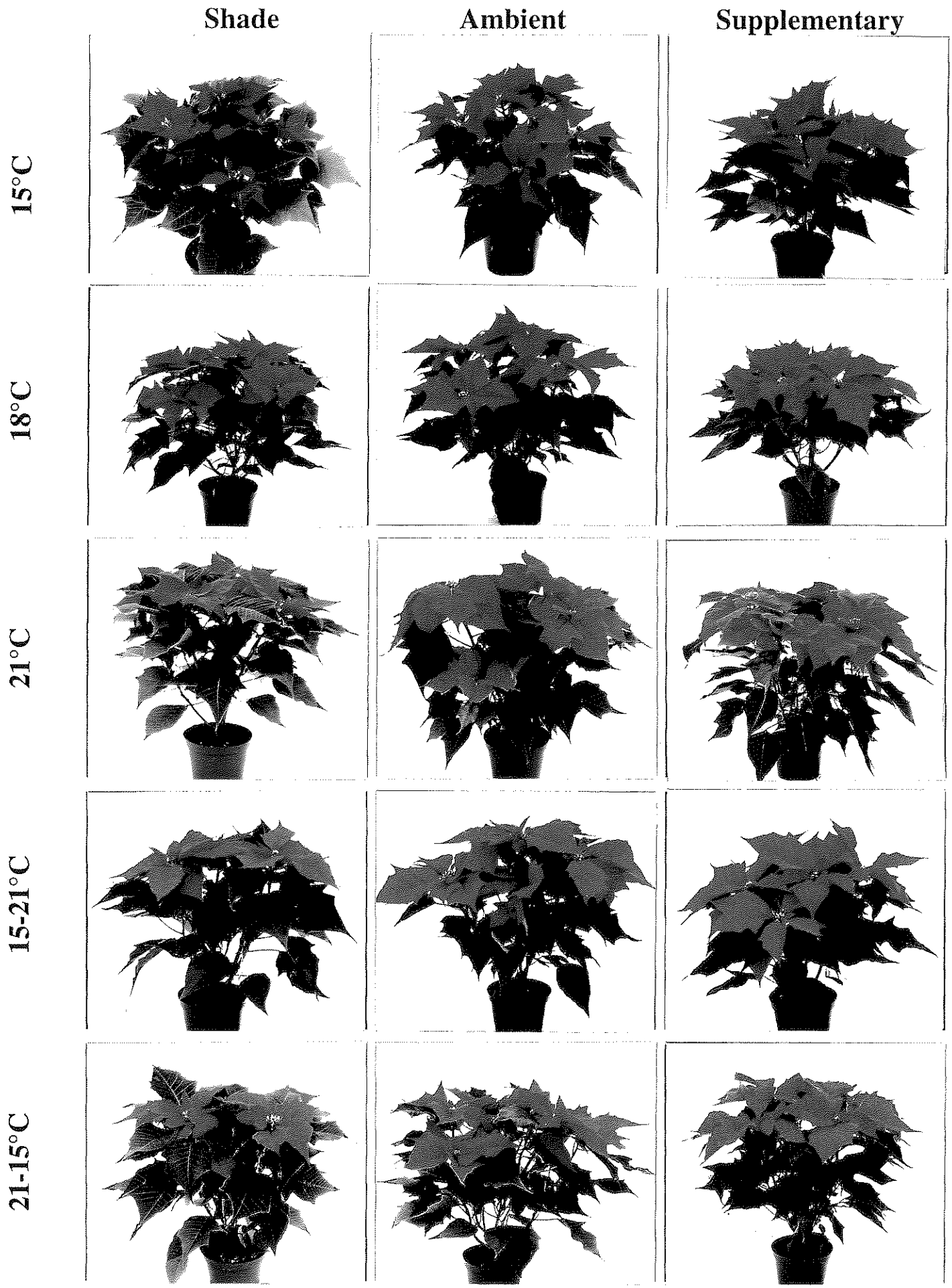


Plate 3 : Effects of temperature applied from week 43 on Poinsettia "Spotlight" grown in three different lighting environments.

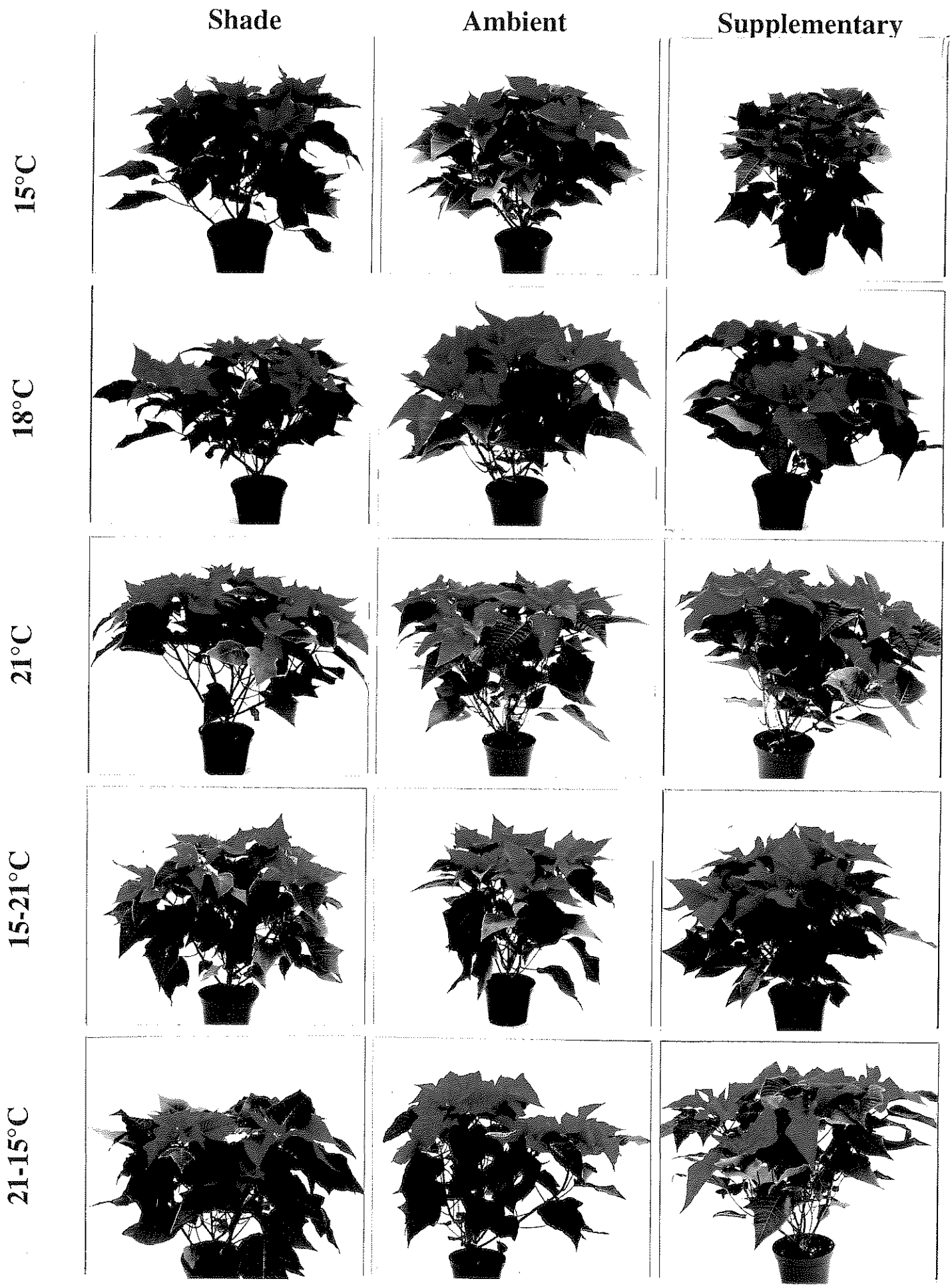


Plate 4 : Effects of temperature applied from week 43 on Poinsettia "Freedom" grown in three different lighting environments.

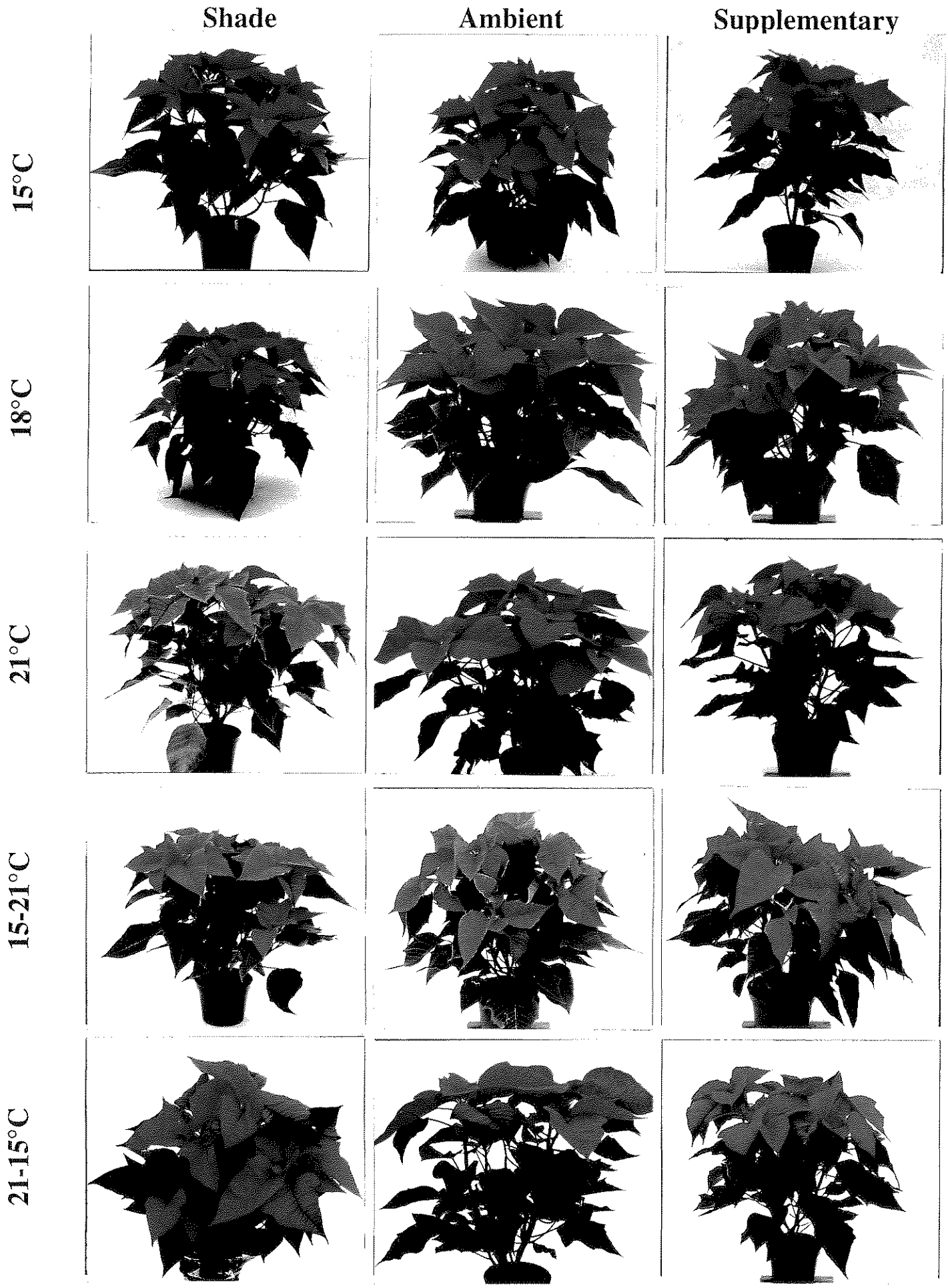


Plate 5: Effects of temperature applied from week 43 on Poinsettia "Lilo" grown in three different lighting environments.

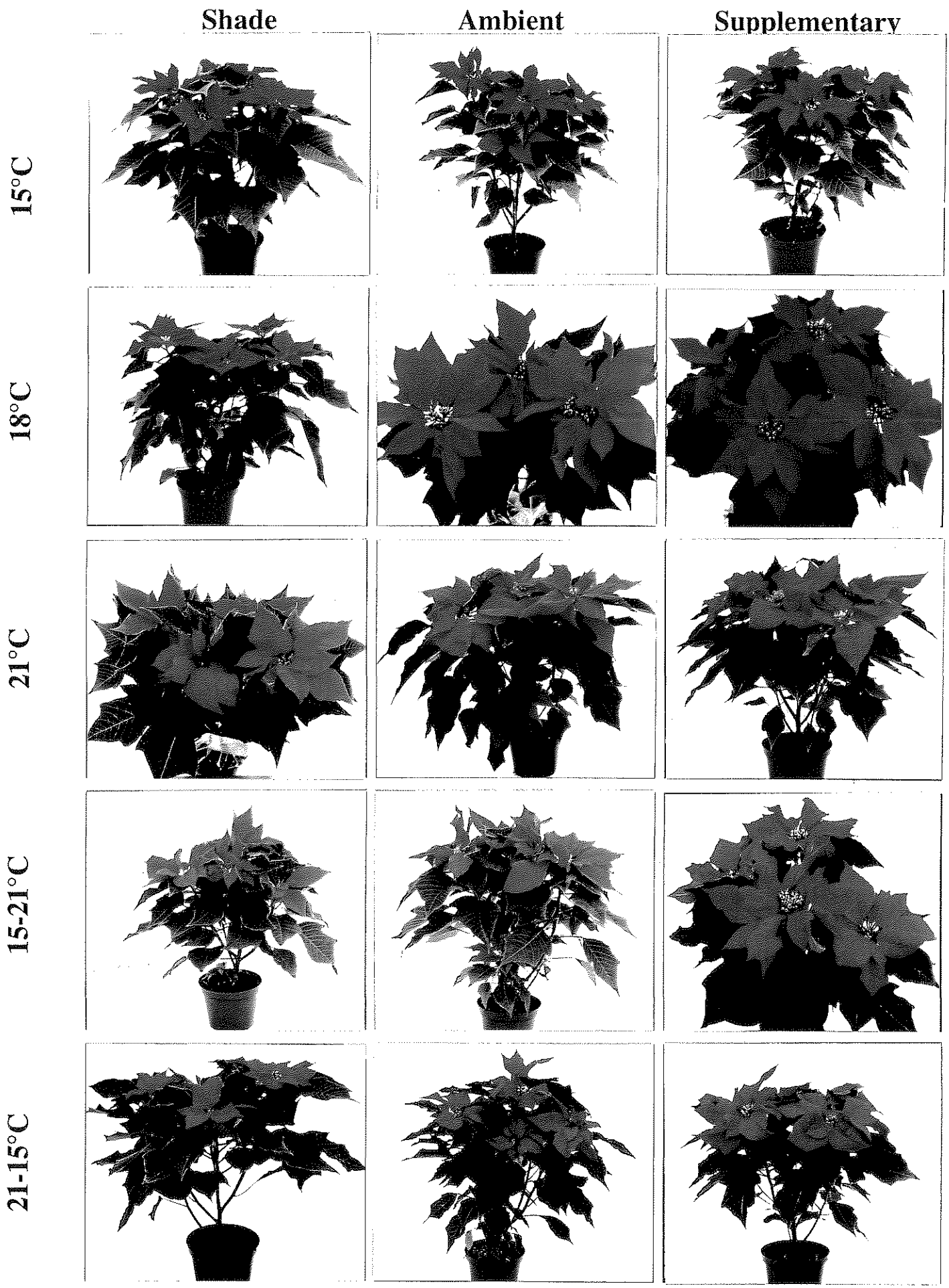


Plate 6: Effects of temperature on physiological development at marketing in Poinsettia "Lilo".

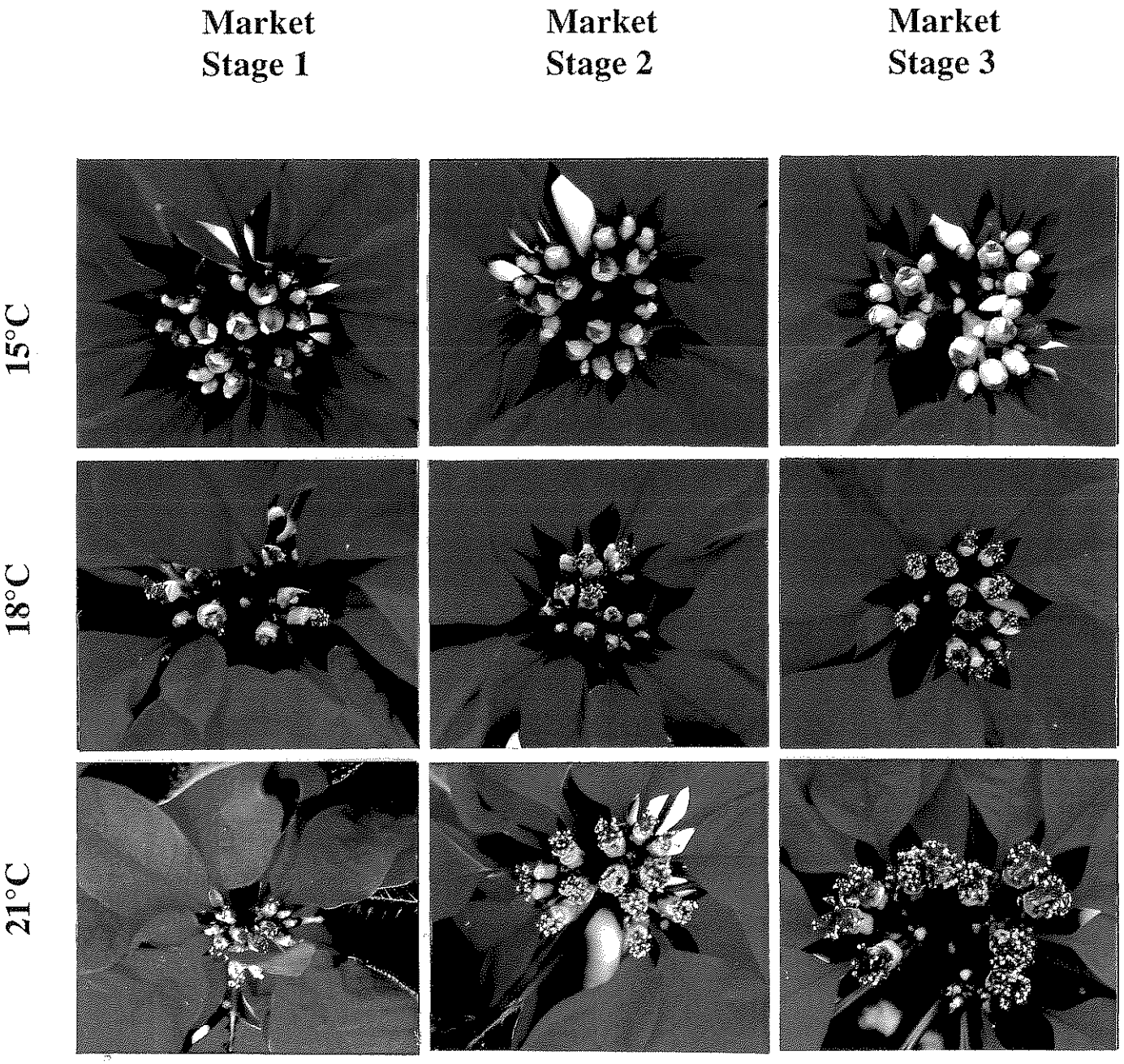


Plate 7 : Effects of temperature on physiological development at marketing in Poinsettia "Spotlight".