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CONTRACT REPORT

Chrysanthemums: The Influence of Supplementary Lighting and DROP Regimes on the Winter Quality of American bred varieties of pot chrysanthemums

HDC PC92
1993/94

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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.

Signature ..... Dr D J Hand
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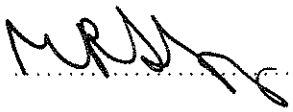
Report authorised by  M R Shipway
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HDC PC92

Chrysanthemums: The influence of supplementary lighting and DROP regimes on the winter quality of American bred varieties of pot chrysanthemums

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Co-ordinator: Mr D Abbott

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Key words: Chrysanthemum, DIF, DROP, Supplementary Lighting, Plant Stature

RELEVANCE TO GROWERS AND PRACTICAL APPLICATION

Application

DROP treatments for control of plant stature combined with supplementary lighting for improvements in winter quality and production time were evaluated for potential interaction effects. The quality benefits of supplementary lighting (particularly at 4.8 W/m^2 or 2000 lux throughout S.D.) were not influenced by DROP treatment but slight delays resulted from the use of DROP over the first three weeks of short days. DROP treatments successfully reduced plant height but were not sufficient to completely replace standard chemical plant growth regulator treatments.

Observation studies on pot spacing indicated that closer spacing treatments could yield 16-22% savings on the cost per pot due to supplementary lighting. These savings would have to be balanced against the slight delays in production time and decrease in quality recorded in comparison with standard spacing.

Summary

i. Background and trial details

Supplementary lighting has become an established technique for the production of pot chrysanthemums during the winter period when poor daylight becomes a limiting factor. HDC funded trials conducted at HRI Efford (PC 13b and PC 13c) have identified the two effective supplementary lighting regimes for improving the winter quality of commercial pot mums which are:

i) 4.8 W/m^2 (2000 lux) throughout short days,
ii) 12.0 W/m^2 (5000 lux) for the first three weeks of short days.

Further work at HRI Littlehampton and HRI Efford (PC 41) has demonstrated the potential of difference in day/night temperature (DIF) as a method of height control. For winter production of pot mums, it is important to be able to integrate this technique with that of supplementary lighting. Hence the main objective of the HDC project PC 92 was to evaluate the combined effects of supplementary lighting and difference in temperature on winter quality of commercially grown pot mum varieties.

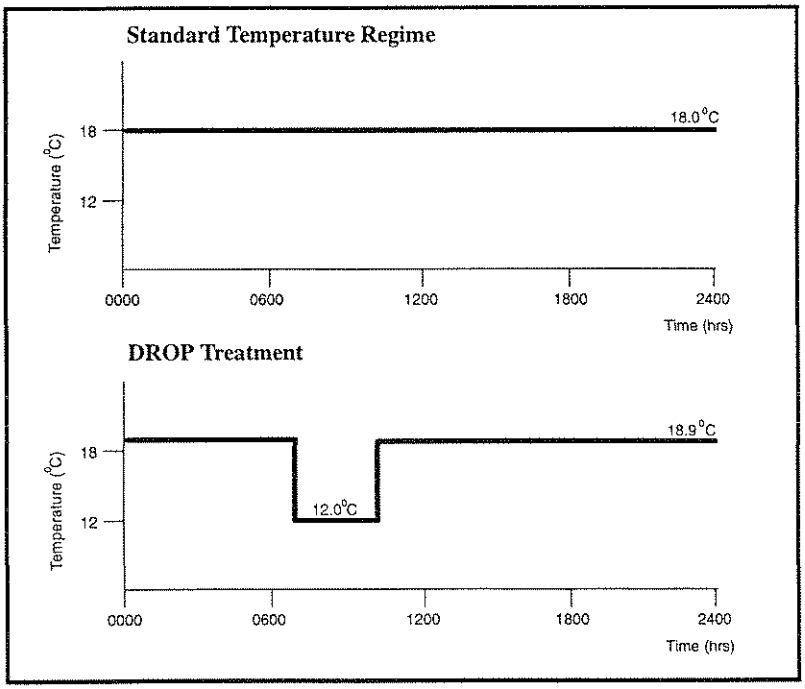
Since supplementary lighting increases total production costs, an observation study on the influence of close spacing was also included. It has also been recognised that supplementary lighting increases irrigation frequency with potential for increasing substrate conductivity levels.

A further observation study was therefore also included to assess the influence of feed treatments (to produce different conductivity levels) on performance of plants in shelf-life.

The three main objectives of the trial may therefore be summarised as:

- evaluation of the combined effects of supplementary lighting and DROP on winter quality;
- examination of the interaction of pot spacing with supplementary lighting and DROP on quality of product and economics of production;
- assessment of the influence of nutrition in combination with supplementary lighting on plant performance under shelf-life conditions.

The term DIF covers any temperature regime where the day and night temperatures are different and one way in which this may be achieved is by changing temperature for a selected period within the day or night. The technique adopted for this investigation involved lowering temperature by 6°C for the three hours following removal of thermal blackout screens (i.e. from 0700 to 1000). This type of DIF regime, termed DROP, was achieved through the natural temperature drop which occurs when thermal screens are removed along with positive venting where necessary. Since trials at HRI Littlehampton illustrated that lowering the 24 hour average temperature delays flowering, the DROP regime was combined with temperature compensation (from 1000 to 0700) to maintain an 18°C average, as illustrated below.



The two supplementary lighting treatments specified above were combined with periods of DROP treatment in the main trial as follows:

i) DROP for the first three weeks of short days (i.e. flower initiation period)
ii) DROP from week 4 of short days to marketing (i.e. flower development and maturation period)
iii) DROP throughout short days
iv) Standard temperature regime (control).

Since the influence of DROP on plant stature was under investigation, chemical plant growth regulators were not applied to main trial plots. One further treatment was included under the 12 W/m^2 (5000 lux) supplementary lighting regime as follows:

v) Standard temperature regime + Daminozide

This was included to provide a comparison of plants which would be raised to commercial standards.

The observation trial on spacing compared the following treatments:

i) standard spacing (24 pots/m^2 at intermediate spacing
12.5 pots/^{2} at final spacing)

ii) close spacing (30 pots/m^2 at intermediate spacing
15 pots/^{2} at final spacing)

Comparisons were again made under the two supplementary lighting regimes detailed above. Each spacing/lighting treatment was also compared under both the standard temperature regime and the DROP throughout short days regime.

The three varieties, Charm, Dark Yellow Boaldi and Miramar, were evaluated under each of the main trial and spacing observation trial treatments. All treatments were repeated on three sticking dates (weeks 41, 45 and 49) to represent a range of low natural light conditions over the winter period.

The observation trial on the influence of nutrition on shelf-life performance compared the following low, standard and high feed treatments under the two supplementary lighting regimes specified above:

i) Low feed (225 N:45 P_2O_5 (20 P):187.5 K_2O (156 K))
ii) Standard feed (300 N:60 P_2O_5 (26 P):250 K_2O (207 K))
iii) High feed (375 N:75 P_2O_5 (33 P):312 K_2O (259 K)).

The varieties Charm and Dark Yellow Boaldi were evaluated for each feed treatment repeated on three sticking dates (weeks 41, 45 and 49).

Plants were assessed for quality at standard marketing stage (i.e. stage 3 - 12 flowers all with petals just bending outwards, 50% of petals at least 20mm long) through records of both plant form and flower development. Additional studies on shelf-life performance were conducted for the nutrition observation trial via records of flower opening and plant deterioration.

ii. Results

Plants treated with DROP were up to 4-8cm shorter than those grown under standard temperatures without growth regulants. Response to DROP was greater for pots stuck in weeks 45 and 49 when solar radiation levels were poorer, and Dark Yellow Boaldi was the most responsive variety to DROP. Height control with DROP used for a short period (i.e. 3 weeks) at the start of short days was less effective than that achieved with DROP over longer periods (i.e. either throughout short days or from week 4 of short days to marketing). DROP was less effective than Daminozide in reducing plant height, particularly for the later sticking dates.

Despite compensating temperatures outside the DROP period to maintain a 24 hour average temperature of 18°C, delays in production time were linked to DROP treatment. These delays were greatest when DROP treatments corresponded with the first three weeks of short days (i.e. flower initiation period) and were also more pronounced under the 12 W/m^2 (5000 lux) supplementary lighting treatment. The maximum delay recorded with the 12 W/m^2 (5000 lux) supplementary lighting regime was 2.8 days but the average delay was 1 day. Where delays were recorded, production time under the 12 W/m^2 (5000 lux) regime remained shorter than comparable treatments under the 4.8 W/m^2 (2000 lux) regime. The advantages of supplementary lighting in terms of reduced production time (for both lighting regimes) and increased bud count (for 4.8 W/m^2 (2000 lux) supplementary lighting throughout short days) may therefore be maintained where DROP treatments are used. The slight delays in production time associated with applying DROP treatments during flower initiation may be minimised by using DROP from week 4 of short days through to marketing where practical (with some losses in the effectiveness on height control).

The height control achieved with the DROP treatments assessed would not be sufficient for most marketing specifications. DROP could, however, reduce either the concentration or frequency of application of chemical growth regulators. DROP was achieved using the natural temperature decrease which occurs when screens are removed and cold air falls from the roof space in

combination with venting. This technique may therefore also offer savings in energy since temperature boosting to offset the natural temperature fall when screens are removed would not be required where DROP treatments are in use.

Close spacing treatments resulted in both a slight stretching of plants (of up to 10% increase in height in the most extreme cases) and slight delays in production time (an average delay of 0.5 days).

Leaf quality and total bud count were also slightly reduced by closer spacings. These effects were similar under both temperature regimes but were more pronounced under the 12 W/m^2 (5000 lux) supplementary lighting regime than the 4.8 W/m^2 (2000 lux) regime. Comparative costings for these spacing treatments produced the following figures of total additional cost per pot for supplementary lighting:

	Standard Spacing p/pot	Close Spacing p/pot
12 W/m^2 (5000 lux) weeks 1-3 of S.D.	11.7	9.4
4.8 W/m^2 (2000 lux) throughout S.D.	17.8	14.7

Hence savings of 17-20% per pot may be achieved using the closer spacing treatments described above. Benefits in terms of cost need to be balanced against the slight reduction in production time and product quality depending particularly on supplementary lighting regime and variety.

There were no consistent trends relative to nutrition treatments. Compost analyses indicated low conductivity levels associated with low feed treatments but standard and high feed treatments were generally equivalent. Hence whilst there was apparently no influence of feed treatment on shelf-life the treatments had not produced the consistent differences in substrate conductivity necessary for any conclusions to be drawn.

iii. Application

In summary, a temperature DROP of 6°C for three hours following the opening of thermal blackout screens:

- Reduces plant height with the greatest reductions achieved where DROP treatment is used throughout short days.

- Is more effective in combination with 12 W/m^2 (5000 lux) supplementary lighting for the first three weeks of short days than with 4.8 W/m^2 (2000 lux) supplementary lighting throughout short days.

- Does not influence the increased bud count achieved using 4.8 W/m^2 (2000 lux) supplementary lighting throughout short days but causes minor production time delays.

Thus DROP treatment would probably need to be used in combination with chemical plant growth regulators but may reduce either concentration or frequency of application required.

Closer pot spacings were found to have a minor influence on plant quality and production time. These effects would need to be balanced against potential savings of 17-20% per pot on lighting costs.

NOTE: For the purpose of this study the conversion factor for units of lux to W/m^2 is taken as 2.4 mW $\equiv$ 1 lux.

EXPERIMENTAL SECTION

INTRODUCTION

The problems associated with the low light levels experienced by UK growers during the winter period are well recognised and have been the subject of a number of trials conducted at Lee Valley EHS and latterly at HRI Efford. Results from these trials have clearly demonstrated the effectiveness of high intensity supplementary lighting in preventing the delays in production time and decline in quality associated with poor light levels.

The most effective lighting regimes for a range of commercial pot 'mum varieties identified through this trial work are:

i) Supplementary lighting at 12.0 W/m^2 (5000 lux) for the first three weeks of short days

ii) Supplementary lighting at 4.8 W/m^2 2000 lux throughout short days

Another emerging technique for the production of a range of pot and bedding plant subjects is the use of difference in temperature regimes for the manipulation of plant height. Work at HRI Littlehampton and HRI Efford (PC 41) has demonstrated the potential of difference in day/night temperature (DIF) as a method of height control. For the winter production of pot 'mums, it is clearly important to assess the interaction of this technique with that of supplementary lighting.

The term DIF covers any temperature regime where the day and night temperatures are different and one method of achieving this is through the manipulation of temperature for a selected period within the day or night. Temperature manipulation may take the form of a temperature decrease for a selected period (termed DROP) or a temperature increase for a selected period (termed JUMP). DROP treatments have been demonstrated to reduce the height of pot 'mums under natural light conditions (Langton, 1993).

Hence the main objective of the HDC project PC 92 was to evaluate the combined effects of supplementary lighting and difference in temperature on winter quality of commercially grown pot 'mum varieties.

Although the quality benefits of these lighting regimes were clearly demonstrated in earlier trials by plant performance, the economic justification of supplementary lighting requires closer attention. Closer pot spacing, for example, could be used to increase the number of plants per unit area and hence improve on the financial returns achieved (assuming no resultant decline in the quality of the pot).

In addition, the supplementary lighting regimes identified above, in particular the 4.8 W/m^2 (2000 lux) treatment throughout short days, may influence the frequency of irrigation/nutrition and in turn may impact on the shelf-life performance of the product.

Hence two observation studies were also conducted as part of PC 92 to examine both the influence of pot spacing on plant performance, and the influence of nutrition on shelf-life performance of winter produced commercial pot 'mum varieties.

OBJECTIVES

The objectives were:

Main Trial	- to evaluate the combined effects of supplementary lighting and DROP on winter quality of commercially grown pot 'mum varieties.
Spacing Observation Trial	- to examine the interaction of pot spacing with supplementary lighting and DROP regimes on quality of product and economics of production.
Nutrition Observation Trial	- to examine the influence of nutrition and its interaction with supplementary lighting regimes on plant performance under shelf-life conditions.

MATERIALS AND METHODS

Treatments - Main Trial

Code	Lighting	Temperature Treatment	Daminozide
A	4.8 w/M² (2000 lux) throughout S.D.	Control, 18°C/18°C	None
B	4.8 W/m² (2000 lux) throughout S.D.	DROP, at start of S.D. Weeks 1, 2 and 3	None
C	4.8 W/m² (2000 lux) throughout S.D.	DROP, from Week 4 of S.D. to marketing	None
D	4.8 W/m² (2000 lux) throughout S.D.	DROP throughout S.D.	None
E	12 W/m² (5000 lux) at start of S.D., Weeks 1, 2 and 3	Control, 18°C/18°C	None
F	12 W/m² (5000 lux) at start of S.D., Weeks 1, 2 and 3	DROP, at start of S.D. Weeks 1, 2 and 3	None
G	12 W/m² (5000 lux) at start of S.D., Weeks 1, 2 and 3	DROP, from Week 4 of S.D. to marketing	None
H	12 W/m² (5000 lux) at start of S.D., Weeks 1, 2 and 3	DROP throughout S.D.	None
J	12 W/m² (5000 lux) at start of S.D., Weeks 1, 2 and 3	Control, 18°C/18°C	Applied as detailed in Appendix I, page 57

Supplementary lighting was provided continuously by 400W high pressure sodium (SON/T) lamps during short days for 11 hours from 0700 - 1800 hrs.

DROP treatments were applied as 6°C drop for 3 hours at dawn (0700 - 1000 hrs) with temperature compensation to achieve 24 hr average of 18°C (see figure 1, page 2). Daily average temperatures were monitored throughout the trial and set points adjusted as necessary to maintain comparable figures across all compartments.

CO_2 was applied in a conventional manner to standard regimes and to DROP treatments after the DROP period.

Varieties: Charm, Dark Yellow Boaldi, Miramar

Sticking Dates: Week 41, Week 45, Week 49

Treatments - Spacing Observation Trial

Code	Spacing Treatment	Lighting	Temperature	Daminozide
A	Standard	4.8 W/m² (2000 lux) throughout S.D.	Control, 18°C/18°C	None
M	Close	4.8 W/m² (2000 lux) throughout S.D.	Control, 18°C/18°C	None
D	Standard	4.8 W/m² (2000 lux) throughout S.D.	DROP throughout S.D.	None
N	Close	4.8 W/m² (2000 lux) throughout S.D.	DROP throughout S.D.	None
E	Standard	12 W/m² (5000 lux) at start of S.D., Weeks 1, 2 and 3	Control, 18°C/18°C	None
O	Close	12 W/m² (5000 lux) at start of S.D., Weeks 1, 2 and 3	Control, 18°C/18°C	None
H	Standard	12 W/m² (5000 lux) at start of S.D., Weeks 1, 2 and 3	DROP throughout S.D.	None
P	Close	12 W/m² (5000 lux) at start of S.D., Weeks 1, 2 and 3	DROP throughout S.D.	None

Supplementary lighting and DROP regimes as specified for main trial.

Spacing treatments:

Standard - intermediate at 24 pots/m²
final at 12.5 pots/m²

Close - intermediate at 30 pots/m²
final at 15 pots/m²

Varieties: Charm, Dark Yellow Boaldi, Miramar

Sticking Dates: Week 41, Week 45, Week 49

Treatments - Nutrition Observation Trial

Code	Nutrition Treatment	Lighting	Temperature	Daminozide
T	Low	4.8 W/m² (2000 lux) throughout S.D.	18°C/18°C	None
V	Standard	4.8 W/m² (2000 lux) throughout S.D.	18°C/18°C	None
W	High	4.8 W/m² (2000 lux) throughout S.D.	18°C/18°C	None
X	Low	12 W/m² (5000 lux) at start of S.D., Weeks 1, 2 and 3	18°C/18°C	As required
Y	Standard	12 W/m² (5000 lux) at start of S.D., Weeks 1, 2 and 3	18°C/18°C	As required
Z	High	12 W/m² (5000 lux) at start if S.D., Weeks 1, 2 and 3	18°C/18°C	As required

Supplementary lighting as specified for main trial.

Nutrition Treatments:

High feed	-	375 N : 75 P_2O_5 (33 P): 312.5 K_2O (259 K)
Standard feed	-	300 N : 60 P_2O_5 (26 P): 250 K_2O (208 K)
Low feed	-	225 N : 45 P_2O_5 (20 P): 187.5 K_2O (156 K)

Varieties: Charm, Dark Yellow Boaldi

Sticking Dates: Week 41, Week 45, Week 49

Design

Main Trial - Supplementary lighting

1	commercial comparison treatment per variety and sticking date
+	
2	lighting treatments
x	
4	DROP/temperature treatments
x	
3	varieties
x	
3	sticking dates
—	
81	plots
—	

Observation Trial - Spacing

2	spacing treatments
x	
2	lighting treatments
x	
2	DROP/temperature treatments
x	
3	varieties
x	
3	sticking dates
—	
72	plots
—	

Observation Trial - Nutrition

3	nutrition treatments
x	
2	lighting treatments
x	
2	varieties
x	
3	sticking dates
—	
36	plots
—	

Observation Trial - Shelf-life of Nutrition Treatments

3	nutrition treatments
x	
2	lighting treatments
x	
2	marketing stages
x	
2	varieties
x	
3	sticking dates
—	
72	plots
—	

One plot = 24 pots (4 rows, 6 pots per row, staggered spacing)
5 plants per pot
10 pots fully guarded and recorded

One plot = 5 pots per marketing stage
(Shelf-life) 5 plants per pot
5 pots per plot recorded

Cultural details

i. Plant material

Cuttings were purchased from Yoder Toddington Ltd.

ii. Propagation (Long Days)

Cuttings were stuck into Fisons Levington M2 in 140mm half pots (14D) with 5 cuttings per pot. Bench heating was applied to achieve a compost temperature of 20°C. After sticking, pots were covered with clear polythene which remained in place for 10 days before weaning the plants off. Night break lighting during the long day period (14 days) was supplied for 5 hours per night using tungsten lamps (8 minutes on, 8 minutes off cycle).

iii. Short Day environment

As illustrated in figure 1, the temperature for the control (i.e. non DROP) treatments was set at 18°C day and night with ventilation at 21°C and thermal screen cover from 1800 to 0700. The temperature regime for the DROP treatments was set at 12°C with ventilation at 15°C from 0700 to 1000 and at 18.9°C with ventilation at 21.9°C from 1000 to 0700 (to achieve a 24 hour average of 18°C).

Enrichment with pure CO_2 to 1000 vpm was given when the vents were less than 5% open and to 500 vpm with vents at or above 5% open.

iv. Growth regulation

Plants were pinched at approximately 7 to 8 leaves. Chemical growth regulators were applied to selected treatments only (see tables summarising treatments above, pages 10-12) with rates and timing as appropriate to variety and stage of development (Appendix I, page 57).

v. Pot spacing

Pots were placed at 41 pots/m^2 during propagation, moved to an intermediate spacing of 24 pots/m^2 at the beginning of short days and placed at a final spacing of 12.5 pots/m^2 two weeks later. Pots in the close spacing treatments, however, were spaced as specified in the table summarising the treatments for this observation trial above (page 11).

vi. Nutrition

Liquid feeding commenced at the start of short days and continued with every watering. The feed for the main trial, observation spacing trial and control plots in the observation nutrition trial supplied 300 mg/l N, 60 mg/l P_2O_5 (26 mg/l P) and 250 mg/l K_2O (207 mg/l K). The high and low feed treatments in the observation nutrition trial are specified with the summary treatment table (page 12).

vii. Pest and disease control

A routine spray programme was maintained throughout the trial. Pesticides applied included mancozeb (Karamate Dry Flo, 2 g/l), iprodione (Rovral, 5 g/l), malathion (MTM Malathion 60, 1.8 ml/l), endosulfan (Thiodan, 2 ml/l) and dichlorvos (Nuvan 500 EC, 1 ml/l).

viii. Shelf-life environment (observation nutrition trial only)

Plants were selected at either marketing stage two or three as identified by Yoder Bros Inc. and summarised below:

Stage 2 - 7-12 petals showing colour
7 flowers with petals 20mm long and bending outwards

Stage 3 - 12 flowers all with petals just bending outwards
50% of petals at least 20mm long.

To simulate marketing conditions, plants were sleeved, boxed and stored in a cool chamber (5-6°C) for 2 days. Plants were then removed from boxes and transferred to an environment of 18-20°C lit at 800 lux using warm white fluorescent lamps for 12 hours per day. Sleeves were removed after 1 day in this environment and plants were watered as necessary (no feed applied during shelf-life).

Assessments

Main Trial

The effect of supplementary lighting and DROP treatments on plant quality and production time was assessed at standard marketing stage (i.e. stage 3) by recording:

i. Time taken to reach standard marketing stage (i.e. 12 flowers all with petals just bending outwards, 50% of petals at least 20mm long).

ii. Plant height from stem base to tallest flower.

iii. Maximum and minimum plant spread per pot.

iv. Uniformity of flower development recorded as maximum bud stage per plant as defined by Cockshull and Hughes (1972).

v. Number of buds at stage 1&2, 3&4, 5 and over as defined by Cockshull and Hughes (1972).

vi. Leaf quality assessed as number of leaves with minor, moderate or severe levels of deterioration/damage.

vii. Growing media analyses four and eight weeks after the start of short days.

viii. Daily monitoring of temperature regimes achieved per compartment (including 24 hour averages).

ix. Environmental and solar radiation measurements.

Observation trial - Spacing

The effect of supplementary lighting, DROP and spacing treatments on plant quality and production time was assessed at standard marketing stage (i.e. stage 3) by recording:

i. Time taken to reach standard marketing stage (i.e. 12 flowers all with petals just bending outwards, 50% of petals at least 20mm long).

ii. Plant height from stem base to tallest flower.

iii. Maximum and minimum plant spread per pot.

iv. Uniformity of flower development recorded as maximum bud stage per plant as defined by Cockshull and Hughes (1972).

v. Number of buds at stage 1&2, 3&4, 5 and over as defined by Cockshull and Hughes (1972).

vi. Leaf quality assessed as number of leaves with minor, moderate or severe levels of deterioration.

vii. Growing media analyses four and eight weeks after the start of short days.

Observation Trial - Nutrition

The effect of supplementary lighting and nutrition treatments on plant quality and production time was assessed at standard marketing stage (i.e. stage 3) by recording:

i. Time taken to reach standard marketing stage (i.e. 12 flowers all with petals just bending outwards, 50% of petals at least 20mm long).

ii. Plant height from stem base to tallest flower.

iii. Maximum and minimum plant spread per pot.

iv. Uniformity of flower development recorded as maximum bud stage per plant as defined by Cockshull and Hughes (1972).

v. Number of buds at stage 1&2, 3&4, 5 and over as defined by Cockshull and Hughes (1972).

vi. Leaf quality assessed as number of leaves with minor, moderate or severe levels of deterioration.

vii. Growing media analyses four and eight weeks after the start of short days.

The effect of supplementary lighting, and nutrition treatments on plant performance in shelf-life was assessed for plants selected at marketing stages 2 and 3. The following parameters were recorded at the start of shelf-life (i.e. when pots had been transferred from the cold store and sleeves were removed) and then at weekly intervals over a four week period.

i. Deterioration score per pot.

ii. Flower opening score per pot.

iii. Leaf quality assessed as number of leaves with minor, moderate or severe levels of deterioration/damage.

iv. Growing media analyses at the end of shelf-life.

Statistical analyses

Analysis of variance was carried out to assess the significance of data collected. Replication of treatments was based on time (stick dates) and varieties. Effects examined included lighting, DROP, spacing and nutrition treatments and their interaction with both variety and sticking date.

Standard deviation of both maximum bud stage and plant height per pot were also analysed to indicate variability per pot relative to treatment (where a small standard deviation indicates greater uniformity).

Statistical terms

N.S.	Not significant
L.S.D.	The least (minimum) difference when comparing two means within a given column that is required for the means to be statistically different.
$P<0.05$	The probability of this result occurring by chance is equal to or less than 1 in 20 (0.05 = 5%).
$P<0.01$	The probability of this result occurring by chance is equal to or less than 1 in 100 (0.01 = 1%).
$P<0.001$	The probability of this result occurring by chance is equal to or less than 1 in 1000 (0.001 = 0.1%).

RESULTS

1. Main trial - The influence of supplementary lighting and DROP treatments on winter quality

Full records of treatment means for each sticking date per variety are presented in Appendix II, page 58. The following data highlight key observations from the records collected at standard marketing stage.

1.1 Effect of supplementary lighting and DROP on plant height

As noted in previous trials (PC13b and PC13c), plant height was significantly influenced by the following main factors:

Sticking date - plant height increased with later sticking dates.

Variety - Dark Yellow Boaldi was the tallest of the varieties assessed and Charm the most compact.

a. Influence of DROP on plant height ($P < 0.001$)

Mean plant height (cm)

18/18°C	DROP weeks 1-3 S.D.	DROP week 4 S.D. to marketing	DROP throughout S.D.
24.3	23.8	22.8	22.4

L.S.D. (P = 0.05) = 0.417

DROP treatments significantly reduced average plant height. DROP was more effective when applied over longer time periods, with the greatest height reduction (8%) achieved using DROP throughout S.D.

NOTE: It is not valid to include the standard temperature plus Daminozide treatment in this comparison since this was only combined with one of the lighting treatments. This comparison is, however, made below where the two lighting treatments are separated.

b. **Influence of supplementary lighting x Daminozide on plant height ($P < 0.001$)**

Mean plant height (cm)

2000 lux throughout S.D.	5000 lux weeks 1-3 S.D.	5000 lux weeks 1-3 S.D. + Daminozide
23.4	23.2	19.1

L.S.D. (P = 0.05) = 0.380

Daminozide significantly reduced plant height by an average of 4.2cm (18%) for plants raised under the 12 W/m² (5000 lux) lighting regime. Plant height, however, was not influenced by lighting treatment in the absence of Daminozide. This reinforces observations made previously (PC13c) indicating that the more compact plants produced by the 4.8 W/m² (2000 lux) regime compared with the 12 W/m² (5000 lux) regime, where chemical growth regulators were used on all treatments (PC13b), was due to an interaction between the Daminozide treatment and the lighting regime.

c. **Influence of supplementary lighting x DROP x Daminozide on plant height ($P < 0.001$)**

Mean plant height (cm)

	18/18°C	DROP weeks 1-3 S.D.	DROP week 4 S.D. to marketing	DROP throughout S.D.	18/18°C + Daminozide
2000 lux throughout S.D.	24.6	24.1	22.3	22.5	-
5000 lux weeks 1-3 S.D.	23.9	23.5	23.2	22.3	19.1

L.S.D. (P = 0.05) = 0.481

DROP significantly reduced plant height under both supplementary lighting regimes. A significant interaction was however recorded between lighting regime and DROP treatment where trends in response varied slightly. That is, with 4.8 W/m² (2000 lux) supplementary lighting there was no significant difference between the DROP applied throughout S.D. or DROP applied from week 4 S.D. to marketing. In contrast, with the

12 W/m² (5000 lux) regime, DROP was significantly more effective on plant height when applied over the whole S.D. period rather than from week 4 of S.D. through to marketing.

It is also clear from these figures that under the 12 W/m² (5000 lux) regime, Daminozide was more effective at reducing plant height than any of the DROP treatments.

d. Influence of DROP x variety on plant height (P<0.004)

Mean plant height (cm)

	18/18°C	DROP weeks 1-3 S.D.	DROP week 4 S.D. to marketing	DROP throughout S.D.
Charm	21.4	21.2	20.3	19.9
Dark Yellow Boaldi	27.6	26.8	25.0	25.5
Miramar	23.8	23.4	23.1	21.7

L.S.D. (P = 0.05) = 0.722

There was a significant interaction between variety and DROP treatment. That is, Miramar was only significantly reduced in height when DROP was applied throughout S.D. In contrast Charm and Dark Yellow Boaldi were significantly shorter under the DROP throughout S.D. treatment and the DROP from week 4 of S.D. through to marketing treatment.

e. Influence of DROP x stick week on plant height (P = 0.004)

Mean plant height (cm)

	18/18°C	DROP weeks 1-3 S.D.	DROP week 4 S.D. to marketing	DROP throughout S.D.
Week 41	22.0	22.3	21.2	21.4
Week 45	25.1	24.3	23.2	22.4
Week 49	25.7	24.8	23.9	23.4

L.S.D. (P = 0.05) = 0.722

The height of plants stuck in week 41 was not significantly reduced by any of the DROP treatments. Plants stuck in week 45 or week 49, however, responded to DROP treatment as summarised earlier (i.e. with the greatest response associated with DROP throughout S.D. or from week 4 of S.D. through to marketing).

f. **Influence of variety x supplementary lighting x Daminozide on plant height (P = 0.004)**

Mean plant height (cm)

	2000 lux throughout S.D.	**5000 lux weeks 1-3 S.D.**	**5000 lux weeks 1-3 S.D. + Daminozide**
Charm	21.1	20.3	17.7
Dark Yellow Boaldi	26.0	26.4	19.9
Miramar	23.0	23.0	19.7

L.S.D. (P = 0.05) = 0.659

The influence of Daminozide on plant height under the 12 W/m² (5000 lux) lighting regime varied with variety. Greater control was achieved through treating Dark Yellow Boaldi (an average of 25% shorter) than Miramar or Charm (see Appendix I, page 57 for frequency and rates of application).

g. **Influence of DROP x supplementary lighting x sticking date x variety x Daminozide on plant height**

Mean plant height (cm)

	2000 lux throughout S.D.			5000 lux weeks 1-3 S.D.		
	Charm	Dark Yellow Boaldi	Miramar	Charm	Dark Yellow Boaldi	Miramar
18/18°C						
Week 41	19.2	25.5	21.4	19.4	26.3	20.2
Week 45	23.1	27.2	26.6	21.1	28.4	24.4
Week 49	23.3	30.0	25.4	22.6	28.0	24.8
DROP weeks 1-3 of S.D.						
Week 41	20.0	25.5	20.9	19.2	26.8	21.7
Week 45	22.9	26.9	24.9	19.9	26.7	24.3
Week 49	23.7	27.9	24.3	21.5	27.0	24.2
DROP week 4 of S.D. to marketing						
Week 41	18.7	24.0	20.6	19.2	24.7	20.3
Week 45	20.1	23.8	24.3	21.2	25.9	23.7
Week 49	20.9	25.2	23.5	21.7	26.2	26.1
DROP throughout S.D.						
Week 41	19.4	25.3	20.4	17.5	25.2	20.4
Week 45	21.0	25.0	22.1	19.4	24.9	21.8
Week 49	21.1	26.1	21.8	21.2	26.4	23.6
18/18°C + Daminozide						
Week 41	-	-	-	16.3	19.5	20.2
Week 45	-	-	-	17.2	20.1	19.3
Week 49	-	-	-	19.6	20.1	19.6

1.1.1 Effect of supplementary lighting and DROP on variability of plant height

Uniformity of plant height, measured as standard deviation (where a larger figure indicates greater variability) was influenced by:

Sticking Date	-	greater variability from sticking in weeks 45 and 49
Variety	-	Dark Yellow Boaldi was the least uniform overall.

These observations support previous trial results (PC13c).

Supplementary lighting and DROP had no significant influence over uniformity of plant height.

1.2 Effect of supplementary lighting and DROP on rate of production

As noted in previous studies (PC13b and PC13c) rate of production was significantly influenced by:

Variety - The fastest production time was achieved with Charm with no significant differences between Miramar and Dark Yellow Boaldi.

Supplementary lighting - Production time using 12 W/m² (5000 lux) supplementary lighting for the first three weeks of S.D. was on average 3 days faster than using 4.8 W/m² (2000 lux) supplementary lighting throughout S.D.

The following data highlights other key observations from the records collected at standard marketing stage.

NOTE: Standard marketing stage was taken as stage 3 (in the light of recommended winter marketing stages in PC13c), whereas stage 2 has previously been used. Production time figures will therefore be correspondingly greater throughout in comparison with earlier trials.

a. Influence of DROP on production time ($P < 0.001$)

Mean number of days from sticking to marketing

18/18°C	DROP weeks 1-3 S.D.	DROP week 4 S.D. to marketing	DROP throughout S.D.
76.1	76.7	76.3	76.9

L.S.D. (P = 0.05) = 0.380

DROP applied over the first three weeks of S.D. and throughout S.D. significantly delayed production time (by an average of up to 0.8 days). Using DROP from week 4 of S.D. through to marketing, however, had no significant influence on production time.

b. Influence of supplementary lighting x DROP x Daminozide on production time (P = 0.002)

Mean number of days from sticking to marketing

	18/18°C	DROP weeks 1-3 S.D.	DROP week 4 S.D. to marketing	DROP throughout S.D.	18/18°C + Daminozide
2000 lux throughout S.D.	77.8	77.6	77.8	78.3	-
5000 lux weeks 1-3 S.D.	74.4	75.7	74.8	75.5	74.7

L.S.D. (P = 0.05) = 0.439

There was a significant interaction between lighting regime and DROP treatment on average production time. With 4.8 W/m² (2000 lux) supplementary lighting throughout S.D., the only significant delay in production time was associated with the DROP treatment used throughout S.D. The remaining DROP treatments under this lighting regime had no significant influence over production time. With 12 W/m² (5000 lux) supplementary lighting, however, both the DROP throughout S.D. and DROP for weeks 1-3 S.D. significantly delayed production time (by 1.1 days and 1.3 days respectively).

c. Influence of variety x supplementary lighting x Daminozide on production time (P < 0.001)

	2000 lux throughout S.D.	5000 lux weeks 1-3 S.D.	5000 lux weeks 1-3 S.D. + Daminozide
Charm	76.8	74.2	73.8
Dark Yellow Boaldi	78.1	76.0	75.3
Miramar	78.8	75.1	75.1

L.S.D. (P = 0.05) = 0.601

The influence of lighting regime on production time was greatest for Miramar and smallest for Dark Yellow Boaldi. All varieties, however, were significantly faster (by 2.1 to 3.7 days) under the 12 W/m² (5000 lux) regime compared with the 4.8 W/m² (2000 lux) regime. Daminozide did not significantly influence the production time of any of the varieties grown under the 12 W/m² (5000 lux) regime.

d. Influence of DROP x supplementary lighting x sticking date x variety x Daminozide on production time

Mean number of days from sticking to marketing

	2000 lux throughout S.D.			5000 lux weeks 1-3 S.D.		
	Charm	Dark Yellow Boaldi	Miramar	Charm	Dark Yellow Boaldi	Miramar
18/18°C						
Week 41	78.0	78.0	78.0	76.0	76.0	76.0
Week 45	76.8	78.6	81.2	71.7	75.4	73.9
Week 49	74.9	76.6	78.3	72.2	75.0	73.3
DROP weeks 1-3 of S.D.						
Week 41	78.0	78.0	78.0	76.0	76.0	76.0
Week 45	76.7	78.4	79.5	74.0	77.2	76.7
Week 49	75.5	77.9	76.6	74.1	76.6	74.6
DROP week 4 of S.D. to marketing						
Week 41	78.0	79.0	78.0	77.0	77.0	77.0
Week 45	76.9	78.1	81.3	73.8	75.6	74.1
Week 49	74.9	77.4	76.6	72.0	74.6	72.2
DROP throughout S.D.						
Week 41	79.0	79.0	78.0	77.0	77.0	77.0
Week 45	76.9	78.8	81.0	73.7	76.5	75.1
Week 49	75.7	77.1	79.2	72.5	75.4	75.6
18/18°C + Daminozide						
Week 41	-	-	-	76.0	76.0	76.0
Week 45	-	-	-	73.4	75.1	75.8
Week 49	-	-	-	72.0	74.8	73.6

1.3 Effect of supplementary lighting and DROP on pot maximum and minimum spread

As noted in previous trials, maximum and minimum pot spread was influenced by:

Sticking date - the lowest average maximum and minimum spread was recording from plants stuck in week 45.

Variety - Charm was the most compact and Dark Yellow Boaldi the least compact.

The following data highlights other key observations from the records collected at standard marketing stage.

a. Influence of DROP on maximum and minimum spread (P = 0.006)

Mean maximum and minimum spread (cm)

	18/18°C	DROP weeks 1-3 S.D.	DROP week 4 S.D. to marketing	DROP throughout S.D.
Max.	41.6	40.5	39.3	39.4
Min.	37.2	36.6	35.7	35.7

L.S.D. (P = 0.05) = 0.722 max.
1.066 min.

All DROP treatments significantly reduced maximum and minimum pot spread in comparison with the standard temperature regime. Consistent with observations on plant height above, DROP was also more effective on reducing maximum and minimum spread when applied over longer time periods (i.e. throughout S.D. or from week 4 S.D. to marketing).

b. **Influence of supplementary lighting x Daminozide on maximum and minimum pot spread ($P < 0.001$)**

Mean maximum and minimum spread (cm)

	2000 lux throughout S.D.	5000 lux weeks 1-3 S.D.	5000 lux weeks 1-3 S.D. + Daminozide
Max.	41.0	39.5	36.3
Min.	37.0	35.5	33.3

L.S.D. (P = 0.05) = *0.601 max.*
0.992 min.

In the absence of plant growth regulators, supplementary lighting at 12 W/m² (5000 lux) for the first 3 weeks of S.D. produced more compact plants than 4.8 W/m² (2000 lux) throughout S.D.

In contrast, earlier studies (PC13c) found no significant differences in maximum or minimum pot spread due to supplementary lighting when Daminozide treatments had been applied. This observation further supports the evidence of enhanced activity of Daminozide in combination with 4.8 W/m² (2000 lux) supplementary lighting throughout S.D.

In the current trial, Daminozide further reduced maximum and minimum spread of plants grown under 12 W/m² (5000 lux) supplementary lighting for the first three weeks of S.D.

c. **Influence of variety x supplementary lighting x Daminozide on maximum and minimum pot spread ($P < 0.001$)**

Mean maximum and minimum spread

		2000 lux throughout S.D.	5000 lux weeks 1-3 S.D.	5000 lux weeks 1-3 S.D. + Daminozide
Charm	Max.	37.0	36.4	34.8
	Min.	33.5	33.2	32.0
Dark Yellow Boaldi	Max.	44.2	43.9	39.4
	Min.	39.6	39.1	35.8
Miramar	Max.	41.7	38.0	35.4
	Min.	37.8	34.2	32.1

L.S.D. (P = 0.05) = *1.491 max.*
1.718 min.

There was a significant interaction between variety and supplementary lighting in terms of maximum and minimum pot spread. That is, the difference in pot spread between the 4.8 W/m^2 (2000 lux) and 12 W/m^2 (5000 lux) lighting regimes (as noted above - b)* was more pronounced for Miramar than for Charm or Dark Yellow Boaldi. Similarly Daminozide had the greatest effect on pot spread with the variety Dark Yellow Boaldi and the least effect on the variety Charm.

1.4 Effect of supplementary lighting and DROP on flower development

The following data highlights key observations from the records collected at standard marketing stage.

1.4.1 Bud expansion and open buds

Previous studies (PC13b and PC13c) on supplementary lighting have been recorded at marketing stage 2 and have focused on number of buds at stages 3 and 4 (Cockshull and Hughes, 1972) to indicate bud expansion. Since PC13c demonstrated the benefits of later marketing stages, the current trial was recorded at a more advanced stage as described above. Hence, the relative proportions of buds at stages 3 and 4 (i.e. expanding) to buds at stage 5 and over (i.e. open buds) may be expected to be different in the current trial. Both of these sets of data are therefore included in the following observations.

a. Influence of DROP on expanding ($P=0.03$) and open ($P<0.001$) buds

Mean number of buds per pot

	18/18°C	DROP weeks 1-3 S.D.	DROP week 4 S.D. to marketing	DROP throughout S.D.
Stages 3 & 4	13.9	15.2	13.5	14.9
Stage 5+	24.0	20.6	24.8	23.2

L.S.D. (P = 0.05) = 1.52 - stages 3 & 4
1.62 - stage 5+

DROP for the first three weeks of S.D. significantly decreased the number of open buds but did not significantly influence the number of expanding buds.

b. **Influence of supplementary lighting x Daminozide on expanding ($P < 0.001$) and open ($P < 0.001$) buds**

Mean number of buds per pot

	2000 lux throughout S.D.	5000 lux weeks 1-3 S.D.	5000 lux weeks 1-3 S.D. + Daminozide
Stages 3 & 4	18.9	9.9	8.6
Stages 5+	24.2	22.1	20.1

L.S.D. (P = 0.05) = 1.38 - stages 3 & 4
1.48 - stages 5+

There were significantly higher numbers of expanding (stages 3 & 4) and open buds (stage 5+) on plants receiving the 4.8 W/m^2 (2000 lux) lighting regime compared with the 12 W/m^2 (5000 lux) regime. The use of Daminozide in combination with the 12 W/m^2 (5000 lux) regime significantly reduced the number of open buds.

There was no significant interaction between supplementary lighting and DROP treatment in terms of number of expanding or open buds.

c. **Influence of sticking date on expanding ($P < 0.001$) and open ($P < 0.001$) buds**

Mean number of buds per pot

	Week 41	Week 43	Week 45
Stages 3 & 4	11.6	13.5	16.2
Stages 5+	26.8	19.5	22.1

L.S.D. (P = 0.05) = 1.01 - stages 3 & 4
1.08 - stages 5+

Later sticking dates significantly increased the number of expanding buds but decreased the number of open buds at point of marketing.

d. **Influence of variety on expanding ($P<0.001$) and open ($P<0.001$) buds**

Mean number of buds per pot

	Charm	Dark Yellow Boaldi	Miramar
Stages 3 & 4	12.7	16.0	12.5
Stages 5+	19.0	30.1	19.3

L.S.D. (P = 0.05) = 1.09 - stages 3 & 4
1.08 - stages 5+

Dark Yellow Boaldi had the highest number of expanding and open buds compared with Charm and Miramar.

e. **Influence of variety x supplementary lighting x Daminozide on expanding ($P=0.008$) and open ($P=0.04$) buds**

Mean number of buds per pot

		2000 lux throughout S.D.	5000 lux weeks 1-3 S.D.	5000 lux weeks 1-3 S.D. + Daminozide
Charm	Stages 3 & 4	17.0	9.1	10.1
	Stages 5+	19.4	18.9	18.1
Dark Yellow Boaldi	Stages 3 & 4	22.4	11.2	9.4
	Stages 5+	32.5	28.9	25.1
Miramar	Stages 3 & 4	17.4	9.3	6.3
	Stages 5+	20.7	18.6	17.0

L.S.D. (P = 0.05) = 2.39 - stages 3 & 4
2.56 - stages 5+

4.8 W/m² (2000 lux) supplementary lighting throughout S.D. significantly increased the number of expanding buds of all varieties as noted above (b). The number of open buds, however, was only significantly higher with the 4.8 W/m² (2000 lux) treatment (compared with the 12.5 W/m² (5000 lux) treatment) for the variety Dark Yellow Boaldi.

Variety also influenced response to Daminozide. Charm, for example, was not influenced by Daminozide in terms of expanding or open buds. Miramar, however, had significantly less expanding buds when treated with Daminozide.

1.4.2 Total number of buds and flowers per pot

As noted in previous trials (PC13b and PC13c) the total number of buds and flowers per pot was significantly influenced by the following main factors:

Sticking date: - later sticking dates reduced the total number of buds and flowers per pot

Variety - Dark Yellow Boaldi produced the highest total number of buds and flowers per pot and Miramar produced the lowest number

Supplementary lighting - 4.8 W/m^2 (2000 lux) supplementary lighting throughout S.D. produced a greater total number of buds and flowers per pot than 12 W/m^2 (5000 lux) for the first three weeks of S.D.

a. Influence of DROP on total number of flowers produced (N.S.)

Mean total number of buds and flowers

18/18°C	DROP weeks 1-3 S.D.	DROP week 4 S.D. to marketing	DROP throughout S.D.
44.2	43.0	44.6	43.9

L.S.D. (P = 0.05) = 1.51

DROP treatment had no significant influence over the total number of buds and flowers produced per pot.

b. **Influence of supplementary lighting x DROP x Daminozide on total number of flowers produced ($P < 0.001$)**

Mean total number of buds and flowers

	18/18°C	DROP weeks 1-3 S.D.	DROP week 4 S.D. to marketing	DROP throughout S.D.	18/18°C + Daminozide
2000 lux throughout S.D.	52.5	52.6	50.3	50.1	-
5000 lux weeks 1-3 S.D.	36.1	33.5	39.0	37.8	34.7

L.S.D. (P = 0.05) = 1.05

Supplementary lighting had a significant influence over the response of total bud and flower count to DROP treatment. That is, under 4.8 W/m^2 (2000 lux) supplementary lighting throughout S.D both DROP from week 4 of S.D. to marketing and DROP throughout S.D. significantly reduced the total bud and flower count per pot (by approximately 2 buds/flowers per pot). The 12 W/m^2 (5000 lux) treatment, however, did not influence response of total bud and flower count to DROP treatment.

c. **Influence of DROP x variety on total number of flowers produced ($P=0.006$)**

Mean total number of buds and flowers

	18/18°C	DROP weeks 1-3 S.D.	DROP week 4 S.D. to marketing	DROP throughout S.D.
Charm	42.5	42.6	43.6	40.4
Dark Yellow Boaldi	53.0	47.9	53.1	52.5
Miramar	36.9	38.6	37.2	39.0

L.S.D. (P = 0.05) = 3.20

Total bud and flower count of both Charm and Miramar was not influenced by DROP treatment. Dark Yellow Boaldi, however, produced significantly less buds and flowers (approximately 5 on average) when treated with DROP for the first three weeks of S.D.

1.4.3 Uniformity of flowering (standard deviation of maximum bud stage)

The average maximum bud stage per pot at marketing was stage 8 (reflecting the later marketing stage compared with previous trials, PC13c). Uniformity of flowering overall was also greater (as indicated by lower standard deviation figures) in the current trial than in previous studies which may again be a reflection of the later marketing stage.

As noted in previous trials (PC13b, PC13c), uniformity of flowering was significantly influenced by the following main factor:

Variety - Miramar had the greatest uniformity of flowering of all the varieties assessed.

a. Influence of DROP on uniformity of flowering (P=0.003)

Mean standard deviation of maximum bud stage

18/18°C	DROP weeks 1-3 S.D.	DROP week 4 S.D. to marketing	DROP throughout S.D.
0.39	0.61	0.28	0.33

L.S.D. (P = 0.05) = 0.20

DROP for the first three weeks of S.D. alone significantly increased variability of flowering. This effect was not observed, however, when DROP was applied throughout the short day period.

1.5 Effect of supplementary lighting and DROP on leaf quality

The leaf quality scores below represent assessments of leaf damage or deterioration where 1 = minor damage, 2 = moderate damage and 3 = severe damage.

DROP treatments and supplementary lighting had no significant influence over leaf quality score. The following effects were however recorded.

a. Influence of sticking date on number of leaves with minor (P=0.04), moderate (P=0.05) or severe (P<0.001) damage

Mean number of leaves per pot

	Week 41	Week 45	Week 49
Score 1	3.1	3.0	3.9
Score 2	0.3	0.3	0.2
Score 3	2.0	0.7	0.6

L.S.D. (P = 0.05) = 0.69 - score 1
0.13 - score 2
0.49 - score 3

The number of leaves per pot with minor damage was greatest from sticking in week 49 whilst the number of leaves per pot with severe damage was greatest from sticking in week 41.

b. **Influence of variety on number of leaves with minor ($P < 0.001$), moderate ($P < 0.001$) or severe ($P = 0.04$) damage**

Mean number of leaves per pot

	Charm	Dark Yellow Boaldi	Miramar
Score 1	2.3	5.8	1.9
Score 2	0.2	0.4	0.1
Score 3	1.1	1.5	0.8

L.S.D. (P = 0.05) = 0.69 - score 1
0.13 - score 2
0.49 - score 3

The highest number of leaves with minor damage, moderate damage and severe damage were recorded with Dark Yellow Boaldi.

2. Spacing observation trial

Full records of treatment means for each sticking date per variety are presented in Appendix III, page 83. The following data highlight key observations from the records collected at standard marketing stage.

2.1 Effect of spacing on plant height

a. **Mean plant height (cm)**

Standard	Close
23.3	23.7

LSD (P=0.05) = 0.215

Closer spacing resulted in a significant stretching in plant height with an average increase of 0.4 cm for all treatments combined.

b. **Influence of spacing x variety on plant height (P=0.023)**

Mean plant height (cm)

	Standard	Close
Charm	20.7	21.3
Dark Yellow Boaldi	26.5	26.4
Miramar	22.7	23.4

LSD (P=0.05) = 0.373

Variety significantly influenced plant height response to spacing. Both Charm and Miramar stretched in response to closer spacing but the height of Dark Yellow Boaldi was not influenced by spacing.

c. Interaction of spacing x supplementary lighting on plant height (P=0.024)

Mean plant height (cm)

	Standard	Close
2000 lux throughout S.D.	23.5	23.6
5000 lux weeks 1-3 S.D.	23.1	23.7

L.S.D. (P=0.05) = 0.304

The increase in plant height observed in response to closer spacing was greatest in association with 12 W/m^2 (5000 lux) supplementary lighting for the first three weeks of short days.

d. Interaction of spacing x DROP on plant height (N.S.)

Mean plant height (cm)

	Standard	Close
18/18°C	24.3	24.6
DROP throughout S.D.	22.4	22.8

The increase in plant height associated with spacing treatment was not influenced by the temperature regimes assessed.

2.2 Effect of spacing on rate of production

a. Influence of spacing on production time (P=0.003)

Mean number of days from sticking to marketing

Standard	Close
76.5	77.0

LSD (P=0.05) = 0.230

Closer spacing caused an average delay of 0.5 days for lighting and temperature regimes combined.

b. Influence of spacing x variety on production time (N.S.)

Mean number of days from sticking to marketing

	Standard	Close
Charm	75.4	76.0
Dark Yellow Boaldi	77.0	77.6
Miramar	77.2	77.5

All varieties responded to closer spacing with the delay in production time as noted in a) above.

c. Interaction of spacing x supplementary lighting on production time (P=0.010)

Mean number of days from sticking to marketing

	Standard	Close
2000 lux throughout S.D.	78.1	78.2
5000 lux weeks 1-3 S.D.	75.0	75.9

L.S.D. (P=0.05) = 0.326

The delay in production time observed in response to closer spacing was greatest (0.9 days overall) for the 12 W/m^2 (5000 lux) supplementary lighting treatment. Differences due to spacing for the 4.8 W/m^2 (2000 lux) treatment were not significant.

d. Interaction of spacing x DROP on production time (N.S.)

Mean number of days from sticking to marketing

	Standard	Close
18/18°C	76.1	76.7
DROP throughout S.D.	76.9	77.4

DROP treatment did not influence response of production time to spacing treatment in comparison with the standard temperature regime.

2.3 Effect of spacing on pot maximum and minimum spread

Influence of spacing on maximum and minimum spread (P=0.007)

	Standard	Close
Max.	40.5	39.0
Min.	36.4	34.5

L.S.D. (P=0.05) = 1.294 max.
1.038 min.

Closer spacing reduced both maximum and minimum pot spread.

There were no significant interactions recorded between maximum and minimum spread and variety, supplementary lighting, or DROP.

2.4 Effect of spacing on flower development

The following data highlights key observations from the records collected at standard marketing stage.

2.4.1 Bud expansion and open buds

Influence of spacing on expanding (P=0.029) and open (P= <0.001) buds

	Standard	Close
Stage 3 & 4	14.4	13.1
Stages 5+	23.6	20.0

L.S.D. (P=0.05) = *1.105 - stages 3 & 4*
0.841 - stages 5+

There were significantly fewer expanding and open buds on plants from close spacing compared with standard spacing.

2.4.2 Total number of buds and flowers per pot

Influence of spacing on total number of flowers produced (P<0.001)

Mean total number of buds and flowers

Standard	Close
44.1	38.4

LSD (P=0.05) = 1.255

Overall, total number of buds and flowers was reduced by 5.7 per pot due to closer pot spacing.

2.4.3 Uniformity of flowering

Influence of spacing on uniformity of flowers ($P < 0.001$)

Mean standard deviation of maximum bud stage

Standard	Close
0.36	0.64

LSD (P=0.05) = .0066

Close spacing significantly increased variability of flowering.

2.5 Effect of spacing on leaf quality

The leaf quality scores below represent assessments of leaf damage or deterioration where 1 = minor damage, 2 = moderate damage and 3 = severe damage.

Influence of spacing on number of leaves with minor (N.S.), moderate (P=0.04) or severe (P=0.04) damage

Mean number of leaves per pot

	Standard	Close
Score 1	3.0	2.9
Score 2	0.20	0.41
Score 3	1.2	1.8

L.S.D. (P=0.05) = *0.19 - score 2*
0.56 - score 3

Overall, low numbers of leaves per pot were found to have either moderate or severe levels of damage. A significant increase in number of both moderately and severely damaged leaves per pot was, however, recorded when pots were spaced closer together.

3. Nutrition Observation Trial

3.1 Effect of nutrition treatment on plants at marketing

Full records of treatment means at marketing for each sticking date per variety are presented in Appendix IV, page 108. As observed in previous trials, treatment with 12 W/m^2 (5000 lux) supplementary lighting produced a shorter production time in comparison with 4.8 W/m^2 (2000 lux) supplementary lighting while 4.8 W/m^2 (2000 lux) supplementary lighting produced the greater total bud count. There were, however, no significant differences in marketing records relating to feed treatments.

3.2 Effect of nutrition treatment on plants during shelf-life

The influence of nutrition treatment on leaf quality (recorded as severity of deterioration or damage) overall plant deterioration and number of dead buds, is presented in Appendix IV, figures 1-24, pages 122-145.

In summary, there were no consistent trends relative to nutrition treatment during shelf-life in any of the parameters recorded. The following trends were recorded in this data:

- Greater numbers of deteriorated leaves (particularly with minor and severe damage) from plants selected for shelf-life simulation at marketing stage 3 compared with marketing stage 2.
- On average, more severely damaged leaves from pots of Dark Yellow Boaldi than from Charm.
- A more advanced plant stage (and therefore more open flowers) throughout shelf-life from pots selected at marketing stage 3 compared with marketing stage 2.
- The first signs of deterioration, assessed on the overall pot (i.e. accounting for both flowers and leaves) were generally recorded after 2 weeks in shelf-life.
- Deterioration scores of the overall pot increased with length of time in shelf-life and generally reached severe deterioration (i.e. an unacceptable pot) after 4 weeks in shelf-life.
- Number of dead buds per pot was generally greater for marketing stage 2 pots than marketing stage 3 and was also higher for Charm than Dark Yellow Boaldi.
- Number of dead buds per pot increased with length of time in shelf-life but this increase occurred earlier for Charm (week 2 of shelf-life) than for Dark Yellow Boaldi (weeks 3-4 of shelf-life).

4. Compost analyses

Full records of compost analyses for each sticking date per variety are presented in Appendix V (page 146), including analyses 4 and 8 weeks after the start of short days and at the end of shelf-life simulation (nutrition observation trial only).

Levels of nutrients in compost samples were generally as would be expected for the stage of crop.

There were no consistent trends relative to either the main supplementary lighting/DROP treatments or the observation spacing treatments. Results from the observation nutrition trial were not as may be expected. There was a general trend of lower nutrient levels associated with the low feed treatments in comparison with the standard and high feed treatments. Differences between the standard and high feed treatments were, however, not apparent.

Nutrient levels did appear to be higher in samples from 4.8 W/m^2 (2000 lux) treatments than the 12 W/m^2 (5000 lux) treatments, particularly for conductivity and nitrate-N analyses and for pots stuck in week 41. This trend was not consistent in all cases, however, and is difficult to assess against the general extent of variation between samples.

5. Photographic records

(Appendix VI, page 167)

6. Economic evaluation

(Appendix VII, page 177)

7. Solar radiation

(Appendix VIII, page 184)

DISCUSSION

The main objective of the trial was to assess the influence of DROP on plant stature in combination with standard supplementary lighting treatments identified in previous trials (PC13b, PC13c). It is clear from the results that the DROP treatment assessed significantly reduces plant height when combined with the standard supplementary lighting regimes. Longer periods of DROP were more effective than short periods and there was a significant interaction between supplementary lighting regime and DROP on the extent of height control. That is, with 4.8 W/m^2 (2000 lux) supplementary lighting throughout S.D., DROP from week 4 of S.D. was as effective in controlling height as DROP throughout S.D. In contrast, with 12 W/m^2 (5000 lux) supplementary lighting weeks 1-3 of S.D., DROP throughout S.D was more effective than DROP from week 4 of S.D.

Response to DROP treatment was also significantly influenced by variety. A reduction of 7-9% in height was achieved with all varieties using DROP throughout S.D. Effectiveness of DROP over shorter periods, however, appeared to be related to overall extension growth, the tallest variety Dark Yellow Boaldi for example was reduced by an average of 9% in height using DROP from week 4 of S.D. By comparison, the shorter varieties, Charm and Miramar, were only reduced in height by 5% and 3% respectively with this treatment. A similar pattern emerges from the interaction of sticking date and DROP treatment on plant height. That is, the shorter plants developed from sticking in week 41 were reduced in height by 3-4% by DROP throughout S.D. or DROP from week 4 of S.D. In comparison, control plants stuck in weeks 45 and 49 were taller and reductions in height were 8-11% and 7-9% respectively for the same DROP treatments. It is also likely, however, that rate of achieving DROP treatments through venting will be faster later in the year when external temperatures are lower. On a practical note, little difficulty was experienced in achieving the required DROP treatment through venting and low temperature set points throughout the trial period.

The influence of DROP on overall plant stature was also demonstrated through the significant reduction in maximum and minimum spread. Similar trends were observed for these records with, for example, greater reductions in maximum and minimum spread where period of DROP treatment increased.

Comparison of DROP with a standard treatment of chemical plant growth regulators, however, illustrated that full height control may not be achieved with the DROP regime assessed. The greatest average reduction in height with the most effective DROP regime in combination with 12 W/m^2 (5000 lux) supplementary lighting was 7% compared with an average reduction of 20% in height for treatment with Daminozide under the same lighting regime.

DROP treatments also resulted in slight delays in production time. These delays were apparently linked to timing of treatment since DROP over the flower initiation period (weeks 1-3 of S.D.) delayed production time but there was no significant difference in production time between control plants and those receiving DROP from week 4 of S.D. Greater delays in production time were recorded when the DROP treatment over the first three weeks of S.D. was combined with the 12 W/m^2 (5000 lux) lighting regime. The greatest delay recorded under such conditions was 2.8 days but overall an average of 1 day was recorded, and even where plants under the 12 W/m^2 (5000 lux) lighting regime were delayed by DROP they still had significantly faster rates of production than corresponding 4.8 W/m^2 (2000 lux) treatments. Since temperature compensation was used as an integral part of the DROP treatments, and daily temperature averages monitored, these delays do not appear to be linked to low daily average temperatures which would be expected to delay flowering (Langton, 1993). During periods of DROP, however, it was not possible for plants to benefit from solar gain before 10.00 hrs due to low vent temperature set points. Control treatments, however, would have benefited under such conditions.

Bud development results illustrated a similar trend to that described above. That is, the average number of open flowers at marketing stage 3 was significantly decreased when DROP treatment corresponded with the period of flower initiation. Variability of flowering also increased where DROP treatment was applied over the first three weeks of S.D.

Quantitative assessments based on the extent and severity of defects such as mechanical damage or disease, indicated no significant influence of DROP treatments on leaf quality. Since DIF treatments in previous trials (Langton, 1993; Sach and Hand, 1994) resulted in yellowing of foliage, a subjective observation of overall leaf colour per plot was made at the final marketing stage. A slightly paler/more yellow foliage colour was in fact associated with plants in DROP treatments at this stage.

Considering the observations made, it is suggested that under 4.8 W/m^2 (2000 lux) supplementary lighting throughout S.D., DROP from week 4 of S.D. to marketing would be the most suitable of the treatments assessed. Equivalent height control may be achieved to that from DROP throughout S.D. under these conditions but risk from delays in production time should be minimised. Since delays in production time are only slight with this lighting treatment (a maximum of 0.7 days in the current trial) it may be considered more practical to use DROP throughout S.D. With 12 W/m^2 (5000 lux) supplementary lighting, however, height control is more effective with DROP throughout S.D. but delays in production time are also greater. Hence a DROP treatment from week 4 of S.D. to marketing may be more appropriate under these conditions.

Since height control with the DROP treatments assessed were less effective than standard chemical plant growth regulator treatments, they would only be suitable for reducing either concentration or frequency of application of chemical treatments. However, the DROP treatment studied also removes the need to boost temperatures prior to opening thermal/blackout screens to compensate for cold air falling from the roof space and may therefore also yield energy savings. The selection of an appropriate DROP treatment would therefore need to be balanced for effectiveness and extent of delay relative to variety and lighting treatment.

Spacing pots at 25% closer density for weeks 1-2 S.D. followed by 20% closer density from week 3 of S.D. onwards resulted in both a slight stretching and delays in production time. The average amount of stretching due to close spacing was 0.4cm (or an increase of 2% over the average height with standard spacing). Both supplementary lighting treatment and variety influenced extent of stretching associated with close spacing. That is, stretching due to close spacing was greater under the 12 W/m^2 (5000 lux) supplementary lighting regime than the 4.8 W/m^2 (2000 lux) regime.

In addition, close spacing had the greatest influence over height of the varieties Charm and Miramar of the varieties assessed. On individual plots, the greatest stretch recorded was a 10% increase over height of the standard treatment which equates to an increase in height of 1.8cm for Charm stuck in week 41 under 12 W/m^2 (5000 lux) supplementary lighting and DROP throughout S.D., or 2.2cm for Miramar stuck in week 45 under the same conditions. DROP treatment did not significantly influence response of plants to spacing.

The average delay due to closer spacing was 0.5 days. As with stretching discussed above, delay due to closer spacing was greatest for the 12 W/m^2 (5000 lux) lighting treatment (at an average of 0.9 days). Thus in addition to the delays associated with DROP throughout S.D. observed in the main trial, a further delay may be expected if DROP treatment is combined with closer spacing. A similar delay (0.6 days) was however experienced where plants under a standard temperature regime were maintained at the close spacing treatment.

Further effects observed with closer spacing included a decrease in both maximum and minimum pot spread (by an average of 4% and 5% respectively relative to standard spacing), a decrease in numbers of developing, open and total buds per pot and an increase in variability of flowering. Quantitative assessments of damaged/diseased leaves also indicated a decline in leaf quality associated with closer spacing.

There are, therefore, a number of negative effects with close spacing as may be expected. It should be noted, however, that these effects on the whole are relatively minor for individual parameters and do vary with cultural conditions, particularly supplementary lighting. Effects may be reduced, for example where supplementary lighting at 4.8 W/m^2 (2000 lux) is used throughout S.D. in comparison with 12 W/m^2 (5000 lux) for weeks 1-3 S.D. when plants

actually spend the majority of the S.D. period under natural light conditions and hence may be subject to greater light competition. Economic evaluations indicated a saving of 17-20% on costs due to supplementary lighting through the closer spacing assessed. Overall the decision to utilise closer spacing would need to balance the economics against the negative aspects identified and the market specification of the outlet in question.

Nutrition treatments were primarily designed to evaluate the theory that with 4.8 W/m^2 (2000 lux) supplementary lighting, the increase in irrigation frequency necessary to compensate for greater transpiration would result in elevated feed levels accumulating which may in turn impact performance in shelf-life. It is clear from both marketing records and shelf-life records that there were no significant differences associated with nutrition treatment. It is somewhat surprising that the low feed treatment in particular did not influence marketing records and similarly there were no consistent trends in compost analyses relative to nutrition treatment. It is possible that because the feed treatments were not isolated onto discrete benches there may have been some cross contamination of nutrients between treatments.

CONCLUSIONS

This study has illustrated that a DROP treatment of 6°C for three hours from 0700 (i.e. from removing thermal/blackout screens):

- reduces plant height when supplementary lighting is used either at 4.8 W/m² (2000 lux) throughout S.D. or at 12 W/m² (5000 lux) for weeks 1-3 S.D.
- is more effective when used over a greater proportion of the S.D. period and in association with the 12 W/m² (5000 lux) lighting treatment.
- may result in production time delays if used during flower initiation.
- does not control plant height under the 12 W/m² (5000 lux) lighting treatment as effectively as a standard plant growth regulator treatment.

Observations on spacing treatments indicate that pots may be grown at closer spacing (i.e. 25% closer during intermediate spacing and 20% closer during final spacing) with a slight impact on plant form and quality.

RECOMMENDATIONS FOR FURTHER WORK

DROP treatments have been illustrated to have an effect on plant stature under supplementary lighting but are not sufficient to replace plant growth regulators. A full DIF treatment where day temperature is lower than night temperature may be more effective on controlling plant stature but also needs to be assessed on supplementary lighting treatments which may be used commercially. Other cultural methods for controlling plant height, such as manipulating phosphorus nutrition which has had a significant influence on bedding plants (PC86) would provide a further interesting extension to this work.

The DROP treatment assessed required more venting for DROP compartments than control compartments for the temperature decrease required. During the DROP period, therefore, CO_2 levels in DROP compartments were lower than those in control compartments which may have contributed to the results observed. Further studies on the impact of CO_2 on Chrysanthemum production may therefore be valuable.

Closer spacing had a slight detrimental impact on plant quality, particularly where plants spent the majority of the S.D. period in natural light. It may therefore be possible to achieve acceptable quality with even close spacings, particularly if supplementary lighting is used throughout the S.D. period. The influence of closer spacing on shelf-life performance must also be evaluated.

An additional method of increasing light receipt per plant may also be to decrease spacing density. This may be achieved in combination with reducing labour inputs by moving plants from initial spacing directly to final spacing. To minimise risks to plant establishment and optimise space utilisation such a treatment may involve an additional week at initial spacing before moving pots to final spacing.

It is also recognised that attention has focused in recent trials on the two lighting treatments of 4.8 W/m^2 (2000 lux) throughout S.D. or 12 W/m^2 (5000 lux) for weeks 1-3 of S.D. independently. The benefits of these independent treatments may, however, be combined by using both treatments on the same crop. Hence commencing the S.D. period under the higher light intensity and moving to a lower intensity after flower initiation may yield a combination of the production speed and quality benefits recorded for the two treatments independently. Furthermore, since the plants would be receiving supplementary lighting throughout production it may be possible to achieve the closer spacing treatments suggested above.

Hence it would be valuable to undertake studies on the following:

a) Evaluate the influence of combined supplementary lighting on winter quality in conjunction with the possibility of even closer spacing treatments than those assessed in the current trial.

b) Examine the potential for improving winter quality by manipulating spacing in the absence of supplementary lighting.

c) Investigate the influence of negative DIF treatments on quality under standard supplementary lighting treatments.

d) Investigate the impact of CO_2 levels of crop development and quality.

APPENDIX I

Chemical growth regulation - rates of *Daminozide application

Variety	Stick Date Week 41 g/l	ppm	Week 45 g/l	ppm	Week 49 g/l	ppm
Charm	2.4+1.5	2000+1250	2.4+1.5	2000+1250	1.5	2000+1250
Dark Yellow Boaldi	1.5	1250	1.5	1250	1.5	1250
Miramar	NIL	NIL	1.5	1250	1.5	1250

Chemical growth regulation - dates of *Daminozide application

Variety	Stick Date Week 41	Week 45	Week 49
Charm	13.11.93 (1st) 23.11.93 (2nd)	10.12.93 (1st) 22.12.93 (2nd)	14.01.94 (1st) 25.01.94 (2nd)
Dark Yellow Boaldi	13.11.93	10.12.93	13.01.94
Miramar	-	14.12.93	14.01.94

* Plant growth regulators were utilised in the observation nutrition trial and the commercial comparison treatment (i.e. 18/18°C plus Daminozide) in the main trial only. The chemical applied at these rates had an active ingredient content of 85%.

APPENDIX II

MAIN TRIAL: **Influence of the combined effects of supplementary lighting and DROP - Tables of Results**

Table 1: **Effect of DROP treatment and supplementary lighting on plant height (assessed at standard marketing stage)**

a. **4.8 W/m² (2000 lux) supplementary lighting throughout S.D.**

Variety	Average plant height (cm) relative to treatment			
	A	B	C	D
Stick Date: Week 41				
Charm	19.2	20.0	18.7	19.4
Dark Yellow Boaldi	25.5	25.5	24.0	25.3
Miramar	21.4	20.9	20.6	20.4
Stick Date: Week 45				
Charm	23.1	22.9	20.1	21.0
Dark Yellow Boaldi	27.2	26.9	23.8	25.0
Miramar	26.6	24.9	24.3	22.1
Stick Date: Week 49				
Charm	23.3	23.7	20.9	21.1
Dark Yellow Boaldi	30.0	27.9	25.2	26.1
Miramar	25.4	24.3	23.5	21.8
Statistical mean	24.6	24.1	22.3	22.5

DROP treatment

A Standard temperature regime (18/18°C)
B DROP weeks 1, 2 and 3 of S.D.
C DROP week 4 of S.D. to marketing
D DROP throughout S.D.

All figures represent mean values of 10 replicate pots per plot.

b. **12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.**

Variety	Average plant height (cm) relative to treatment				
	E	F	G	H	J
Stick date: Week 41					
Charm	19.4	19.2	19.2	17.5	16.3
Dark Yellow Boaldi	26.3	26.8	24.7	25.2	19.5
Miramar	20.2	21.7	20.3	20.4	20.2
Stick date: Week 45					
Charm	21.1	19.9	21.2	19.4	17.2
Dark Yellow Boaldi	28.4	26.7	25.9	24.9	20.1
Miramar	24.2	24.3	23.7	21.8	19.3
Stick date: Week 49					
Charm	22.6	21.5	21.7	21.2	19.6
Dark Yellow Boaldi	28.0	27.0	26.2	26.4	20.1
Miramar	24.8	24.2	26.1	23.6	19.6
Statistical mean	23.9	23.5	23.2	22.3	19.1

DROP treatment

E Standard temperature regime (18/18°C)
F DROP weeks 1, 2 and 3 of S.D.
G DROP week 4 of S.D. to marketing
H DROP throughout S.D.
J Standard temperature regime (18/18°C) + Daminozide

All figures represent mean values of 10 replicate pots per plot

Table 2: **Effect of DROP treatment and supplementary lighting on variability of plant height (assessed at standard marketing stage)**

a. **4.8 W/m² (2000 lux) supplementary lighting throughout S.D.**

Variety	Average standard deviation* of plant height relative to treatment			
	A	B	C	D
Stick Date: Week 41				
Charm	1.1	1.4	1.3	1.2
Dark Yellow Boaldi	1.4	1.1	1.2	1.0
Miramar	1.1	1.1	0.9	1.2
Stick Date: Week 45				
Charm	1.3	1.1	1.1	1.3
Dark Yellow Boaldi	1.1	1.0	1.1	1.3
Miramar	1.3	1.2	1.1	1.5
Stick Date: Week 49				
Charm	1.4	1.6	1.6	1.1
Dark Yellow Boaldi	1.6	1.5	1.2	1.4
Miramar	1.1	1.1	0.9	1.2
Statistical mean	1.3	1.2	1.2	1.3

DROP treatment

A Standard temperature regime (18/18°C)
B DROP weeks 1, 2 and 3 of S.D.
C DROP week 4 of S.D. to marketing
D DROP throughout S.D.

* A larger figure of standard deviation indicates greater variability in height.

All figures represent mean values of 10 replicate pots per plot.

b. **12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.**

Variety	Average standard deviation* of plant height relative to treatment				
	E	F	G	H	J
Stick date: Week 41					
Charm	1.4	1.1	1.1	1.0	1.5
Dark Yellow Boaldi	1.5	1.5	1.2	1.3	1.2
Miramar	1.2	1.0	1.0	1.0	0.9
Stick date: Week 45					
Charm	1.4	1.6	1.3	1.3	1.1
Dark Yellow Boaldi	1.2	1.5	1.3	1.4	1.5
Miramar	1.5	1.5	1.5	1.1	1.3
Stick date: Week 49					
Charm	1.4	1.3	1.3	1.1	1.1
Dark Yellow Boaldi	1.3	1.3	1.6	1.3	1.4
Miramar	1.7	1.3	1.2	1.3	1.0
Statistical mean	1.4	1.4	1.3	1.2	1.2

DROP treatment

E Standard temperature regime (18/18°C)
F DROP weeks 1, 2 and 3 of S.D.
G DROP week 4 of S.D. to marketing
H DROP throughout S.D.
J Standard temperature regime (18/18°C) + Daminozide

* A larger figure of standard deviation indicates greater variability in height.

All figures represent mean values of 10 replicate pots per plot

Table 3: **Effect of DROP treatment and supplementary lighting on production time (assessed at standard marketing stage)**

a. **4.8 W/m² (2000 lux) supplementary lighting throughout S.D.**

Variety	Average number of days from sticking to marketing relative to treatment A	B	C	D
Stick Date: Week 41				
Charm	78.0	78.0	78.0	79.0
Dark Yellow Boaldi	78.0	78.0	79.0	79.0
Miramar	78.0	78.0	78.0	78.0
Stick Date: Week 45				
Charm	76.8	76.7	76.9	76.9
Dark Yellow Boaldi	78.6	78.4	78.1	78.8
Miramar	81.2	79.5	81.3	81.0
Stick Date: Week 49				
Charm	74.9	75.5	74.9	75.7
Dark Yellow Boaldi	76.6	77.9	77.4	77.1
Miramar	78.3	76.6	76.6	79.2
Statistical mean	77.8	77.6	77.8	78.3

DROP treatment

A Standard temperature regime (18/18°C)
B DROP weeks 1, 2 and 3 of S.D.
C DROP week 4 of S.D. to marketing
D DROP throughout S.D.

All figures represent mean values of 10 replicate pots per plot.

b. 12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.

Variety	Average number of days from sticking to marketing relative to treatment				
	E	F	G	H	J
Stick date: Week 41					
Charm	76.0	76.0	77.0	77.0	76.0
Dark Yellow Boaldi	76.0	76.0	77.0	77.0	76.0
Miramar	76.0	76.0	77.0	77.0	76.0
Stick date: Week 45					
Charm	71.7	74.0	73.8	73.7	73.4
Dark Yellow Boaldi	75.4	77.2	75.6	76.5	75.1
Miramar	73.9	76.7	74.1	75.1	75.8
Stick date: Week 49					
Charm	72.2	74.1	72.0	72.5	72.0
Dark Yellow Boaldi	75.0	76.6	74.6	75.4	74.8
Miramar	73.3	74.6	72.2	75.6	73.6
Statistical mean	74.4	75.7	74.8	75.5	74.7

DROP treatment

E Standard temperature regime (18/18°C)
F DROP weeks 1, 2 and 3 of S.D.
G DROP week 4 of S.D. to marketing
H DROP throughout S.D.
J Standard temperature regime (18/18°C) + Daminozide

All figures represent mean values of 10 replicate pots per plot

Table 4: **Effect of DROP treatment and supplementary lighting on maximum and minimum pot spread (assessed at standard marketing stage)**

a. **4.8 W/m² (2000 lux) supplementary lighting throughout S.D.**

Variety		Average plant spread (cm) relative to treatment A	B	C	D
Stick date: Week 41					
Charm	Max.	38.7	36.9	36.2	36.8
	Min.	34.9	33.3	33.2	34.3
Dark Yellow Boaldi	Max.	48.8	44.5	40.1	43.9
	Min.	41.0	39.7	37.6	39.2
Miramar	Max.	42.3	42.9	35.6	38.2
	Min.	38.3	38.5	32.6	34.3
Stick date: Week 45					
Charm	Max.	36.6	35.5	34.0	34.5
	Min.	32.4	32.1	30.7	31.5
Dark Yellow Boaldi	Max.	44.5	43.3	42.0	43.4
	Min.	38.5	39.0	38.4	37.3
Miramar	Max.	43.0	43.0	42.7	41.2
	Min.	39.1	37.1	38.4	37.9
Stick date: Week 49					
Charm	Max.	39.3	38.7	37.5	39.8
	Min.	36.0	34.9	33.7	35.3
Dark Yellow Boaldi	Max.	47.2	43.8	44.9	43.8
	Min.	43.4	40.0	40.1	41.2
Miramar	Max.	44.3	42.9	41.2	42.7
	Min.	40.4	40.7	38.1	38.2
Statistical mean	Max.	42.7	41.3	39.4	40.5
	Min.	38.2	37.3	35.9	36.6

DROP treatment

A Standard temperature regime (18/18°C)
B DROP weeks 1, 2 and 3 of S.D.
C DROP week 4 of S.D. to marketing
D DROP throughout S.D.

All figures represent mean values of 10 replicate pots per plot

b. 12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.

Variety		Average plant spread (cm) relative to treatment E	F	G	H	J
Stick date: Week 41						
Charm	Max.	37.4	36.0	36.4	35.4	34.5
	Min.	34.3	33.3	32.9	31.9	31.5
Dark Yellow Boaldi	Max.	46.3	46.0	42.0	40.9	38.8
	Min.	40.4	40.2	37.0	36.8	35.7
Miramar	Max.	37.8	38.1	36.0	35.1	37.8
	Min.	33.9	33.4	33.6	33.0	34.0
Stick date: Week 45						
Charm	Max.	35.1	34.6	34.4	33.7	32.2
	Min.	31.6	30.4	30.5	29.6	28.8
Dark Yellow Boaldi	Max.	43.0	39.3	42.3	41.3	38.8
	Min.	37.6	36.1	37.3	36.3	34.0
Miramar	Max.	34.7	36.3	37.4	36.5	32.2
	Min.	30.8	31.5	32.3	32.0	28.4
Stick date: Week 49						
Charm	Max.	38.7	37.8	38.8	38.6	37.8
	Min.	35.5	35.4	35.9	36.5	35.5
Dark Yellow Boaldi	Max.	49.6	47.8	44.7	44.1	40.7
	Min.	42.2	44.3	41.5	39.6	37.8
Miramar	Max.	42.1	40.7	41.7	39.8	36.1
	Min.	38.8	38.0	36.7	37.0	33.9
Statistical mean	Max.	40.5	39.6	39.3	38.4	36.5
	Min.	36.1	35.8	35.3	34.7	33.3

DROP treatment

E Standard temperature regime (18/18°C)
F DROP weeks 1, 2 and 3 of S.D.
G DROP week 4 of S.D. to marketing
H DROP throughout S.D.
J Standard temperature regime (18/18°C) + Daminozide

All figures represent mean values of 10 replicate pots per plot

Table 5: **Effect of DROP treatment and supplementary lighting on bud development (assessed at standard marketing stage)**

a. **4.8 W/m² (2000 lux) supplementary lighting throughout S.D.**

Variety	Average number of buds at stages 1 and 2 relative to treatment A	B	C	D
Stick Date: Week 41				
Charm	8.5	11.7	12.8	11.7
Dark Yellow Boaldi	7.4	6.6	7.1	6.6
Miramar	3.3	4.2	3.0	2.8
Stick Date: Week 45				
Charm	14.4	16.9	16.9	12.1
Dark Yellow Boaldi	4.6	2.9	4.2	3.2
Miramar	9.0	9.4	2.9	2.3
Stick Date: Week 49				
Charm	12.0	17.5	14.6	15.6
Dark Yellow Boaldi	3.8	8.6	3.2	3.0
Miramar	6.4	12.6	6.3	6.8
Statistical mean	7.8	10.0	7.9	7.1

DROP treatment

A Standard temperature regime (18/18°C)
B DROP weeks 1, 2 and 3 of S.D.
C DROP week 4 of S.D. to marketing
D DROP throughout S.D.

All figures represent mean values of 10 replicate pots per plot.

b. **12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.**

Variety	Average number of buds at stages 1 and 2 relative to treatment				
	E	F	G	H	J
Stick date: Week 41					
Charm	5.4	7.0	9.7	6.9	13.9
Dark Yellow Boaldi	7.6	3.4	10.5	5.9	11.3
Miramar	5.5	3.4	5.7	7.0	1.7
Stick date: Week 45					
Charm	7.5	8.5	4.5	4.0	3.5
Dark Yellow Boaldi	1.7	0.8	1.2	0.8	2.0
Miramar	1.0	5.5	2.1	2.5	4.0
Stick date: Week 49					
Charm	5.5	5.3	7.3	6.1	10.2
Dark Yellow Boaldi	6.2	0.9	0.7	0.5	1.6
Miramar	3.4	5.3	2.5	5.9	6.4
Statistical mean	4.9	4.5	4.9	4.4	6.1

DROP treatment

E Standard temperature regime (18/18°C)
F DROP weeks 1, 2 and 3 of S.D.
G DROP week 4 of S.D. to marketing
H DROP throughout S.D.
J Standard temperature regime (18/18°C) + Daminozide

All figures represent mean values of 10 replicate pots per plot

Table 6: **Effect of DROP treatment and supplementary lighting on bud development (assessed at standard marketing stage)**

a. **4.8 W/m² (2000 lux) supplementary lighting throughout S.D.**

Variety	Average number of buds at stages 3 and 4 relative to treatment			
	A	B	C	D
Stick Date: Week 41				
Charm	15.3	15.9	13.0	15.7
Dark Yellow Boaldi	11.7	21.5	14.3	22.0
Miramar	14.1	18.3	21.6	22.4
Stick Date: Week 45				
Charm	22.8	24.5	17.9	13.6
Dark Yellow Boaldi	23.7	24.0	18.3	21.2
Miramar	19.4	19.3	20.3	18.1
Stick Date: Week 49				
Charm	19.7	18.3	10.9	15.8
Dark Yellow Boaldi	29.8	25.4	29.2	28.1
Miramar	15.9	13.1	14.2	11.7
Statistical mean	19.2	20.0	17.7	18.7

DROP treatment

A Standard temperature regime (18/18°C)
B DROP weeks 1, 2 and 3 of S.D.
C DROP week 4 of S.D. to marketing
D DROP throughout S.D.

All figures represent mean values of 10 replicate pots per plot.

b. **12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.**

Variety	Average number of buds at stages 3 and 4 relative to treatment				
	E	F	G	H	J
Stick date: Week 41					
Charm	7.9	6.7	10.6	7.4	10.1
Dark Yellow Boaldi	4.0	10.5	5.9	12.4	3.2
Miramar	3.6	9.9	4.5	9.1	1.5
Stick date: Week 45					
Charm	8.4	8.2	8.9	6.0	8.4
Dark Yellow Boaldi	7.5	10.5	8.1	12.3	5.0
Miramar	6.8	6.8	4.7	9.9	9.0
Stick date: Week 49					
Charm	9.7	12.0	12.5	10.9	11.7
Dark Yellow Boaldi	18.5	14.3	13.3	17.2	20.1
Miramar	12.2	14.6	14.1	15.2	8.3
Statistical mean	8.7	10.3	9.2	11.2	8.6

DROP treatment

E Standard temperature regime (18/18°C)
F DROP weeks 1, 2 and 3 of S.D.
G DROP week 4 of S.D. to marketing
H DROP throughout S.D.
J Standard temperature regime (18/18°C) + Daminozide

All figures represent mean values of 10 replicate pots per plot

Table 7: **Effect of DROP treatment and supplementary lighting on bud development (assessed at standard marketing stage)**

a. **4.8 W/m² (2000 lux) supplementary lighting throughout S.D.**

Variety	Average number of buds at stages 5 and above relative to treatment			
	A	B	C	D
Stick Date: Week 41				
Charm	25.3	23.7	23.8	22.1
Dark Yellow Boaldi	46.1	31.8	39.2	34.3
Miramar	27.0	23.5	20.5	20.0
Stick Date: Week 45				
Charm	14.9	15.7	15.1	15.2
Dark Yellow Boaldi	30.7	30.8	34.9	32.5
Miramar	16.9	17.3	20.8	24.8
Stick Date: Week 49				
Charm	19.6	16.8	20.7	19.4
Dark Yellow Boaldi	27.4	24.7	27.8	29.2
Miramar	19.7	18.3	18.8	20.4
Statistical mean	25.3	22.5	24.6	24.2

DROP treatment

A Standard temperature regime (18/18°C)
B DROP weeks 1, 2 and 3 of S.D.
C DROP week 4 of S.D. to marketing
D DROP throughout S.D.

All figures represent mean values of 10 replicate pots per plot.

b. 12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.

Variety	Average number of buds at stages 5 and above relative to treatment E	F	G	H	J
Stick date: Week 41					
Charm	24.4	19.1	26.6	23.5	21.1
Dark Yellow Boaldi	33.4	25.2	38.4	30.5	29.6
Miramar	23.8	18.0	26.5	23.2	22.0
Stick date: Week 45					
Charm	13.4	11.3	15.0	15.2	13.1
Dark Yellow Boaldi	27.2	19.2	29.0	24.5	22.3
Miramar	13.9	13.4	14.8	14.2	11.2
Stick date: Week 49					
Charm	20.4	16.7	20.7	20.9	20.1
Dark Yellow Boaldi	28.9	26.1	33.3	31.0	23.4
Miramar	19.5	18.6	19.6	17.4	17.7
Statistical mean	22.8	18.6	24.9	22.3	20.1

DROP treatment

E Standard temperature regime (18/18°C)
F DROP weeks 1, 2 and 3 of S.D.
G DROP week 4 of S.D. to marketing
H DROP throughout S.D.
J Standard temperature regime (18/18°C) + Daminozide

All figures represent mean values of 10 replicate pots per plot

Table 8: **Effect of DROP treatment and supplementary lighting on total bud count (assessed at standard marketing stage)**

a. **4.8 W/m² (2000 lux) supplementary lighting throughout S.D.**

Variety	Average total bud count per pot relative to treatment			
	A	B	C	D
Stick Date: Week 41				
Charm	49.1	51.3	49.6	49.5
Dark Yellow Boaldi	65.2	59.9	60.6	62.9
Miramar	44.4	46.0	45.1	45.2
Stick Date: Week 45				
Charm	52.1	57.1	49.9	40.9
Dark Yellow Boaldi	59.0	57.7	57.4	56.9
Miramar	45.3	46.0	44.0	45.2
Stick Date: Week 49				
Charm	51.3	52.6	46.2	50.8
Dark Yellow Boaldi	61.0	58.7	60.2	60.3
Miramar	42.0	44.0	39.3	38.9
Statistical mean	52.2	52.6	50.3	50.1

DROP treatment

A Standard temperature regime (18/18°C)
B DROP weeks 1, 2 and 3 of S.D.
C DROP week 4 of S.D. to marketing
D DROP throughout S.D.

All figures represent mean values of 10 replicate pots per plot.

b. **12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.**

Variety	Average total bud count per pot relative to treatment				
	E	F	G	H	J
Stick date: Week 41					
Charm	37.7	32.8	46.9	37.8	45.1
Dark Yellow Boaldi	45.0	39.1	54.8	48.8	44.1
Miramar	32.9	31.3	36.7	39.3	25.2
Stick date: Week 45					
Charm	29.3	28.0	28.4	25.2	25.0
Dark Yellow Boaldi	36.4	30.5	38.3	37.6	29.3
Miramar	21.7	25.7	21.6	26.6	24.2
Stick date: Week 49					
Charm	35.6	34.0	40.5	37.9	42.0
Dark Yellow Boaldi	51.6	41.3	47.3	48.7	45.1
Miramar	35.1	38.5	36.2	38.5	32.4
Statistical mean	36.1	33.5	39.0	37.8	34.7

DROP treatment

E Standard temperature regime (18/18°C)
F DROP weeks 1, 2 and 3 of S.D.
G DROP week 4 of S.D. to marketing
H DROP throughout S.D.
J Standard temperature regime (18/18°C) + Daminozide

All figures represent mean values of 10 replicate pots per plot

Table 9: **Effect of DROP treatment and supplementary lighting on uniformity of flowering (assessed at standard marketing stage)**

a. **4.8 W/m² (2000 lux) supplementary lighting throughout S.D.**

Variety	Average maximum bud stage* per plant relative to treatment			
	A	B	C	D
Stick Date: Week 41				
Charm	9.0	8.8	9.0	8.8
Dark Yellow Boaldi	8.7	7.9	8.6	8.1
Miramar	7.8	7.7	7.8	7.6
Stick Date: Week 45				
Charm	8.4	8.6	8.4	8.5
Dark Yellow Boaldi	7.6	7.9	7.9	7.9
Miramar	7.6	7.8	8.0	8.0
Stick Date: Week 49				
Charm	8.8	8.4	8.9	8.9
Dark Yellow Boaldi	7.3	7.3	7.5	7.6
Miramar	7.9	7.7	7.8	7.8
Statistical mean	8.1	8.0	8.2	8.1

DROP treatment

A Standard temperature regime (18/18°C)
B DROP weeks 1, 2 and 3 of S.D.
C DROP week 4 of S.D. to marketing
D DROP throughout S.D.

* As defined by Cockshull and Hughes (1972)

All figures represent mean values of 10 replicate pots per plot.

b. **12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.**

Variety	Average maximum bud stage* per plant relative to treatment E	F	G	H	J
Stick date: Week 41					
Charm	9.0	8.9	8.9	8.9	8.8
Dark Yellow Boaldi	7.9	7.4	8.6	7.9	8.1
Miramar	8.0	7.6	8.0	8.0	8.0
Stick date: Week 45					
Charm	8.5	8.2	8.8	8.7	8.7
Dark Yellow Boaldi	7.9	7.6	7.8	7.9	7.8
Miramar	7.9	7.6	7.9	8.0	7.6
Stick date: Week 49					
Charm	9.0	8.8	9.0	9.0	8.9
Dark Yellow Boaldi	7.8	7.8	7.9	7.9	7.8
Miramar	8.0	7.9	8.0	7.9	7.8
Statistical mean	8.2	8.0	8.3	8.3	8.2

DROP treatment

E Standard temperature regime (18/18°C)
F DROP weeks 1, 2 and 3 of S.D.
G DROP week 4 of S.D. to marketing
H DROP throughout S.D.
J Standard temperature regime (18/18°C) + Daminozide

* As defined by Cockshull and Hughes (1972)

All figures represent mean values of 10 replicate pots per plot

Table 10: **Effect of DROP treatment and supplementary lighting on leaf quality (assessed at standard marketing stage)**

a. **4.8 W/m² (2000 lux) supplementary lighting throughout S.D.**

Variety	Average number of leaves per pot with minor deterioration relative to treatment			
	A	B	C	D
Stick Date: Week 41				
Charm	2.4	2.1	2.3	1.7
Dark Yellow Boaldi	7.4	8.2	5.3	4.4
Miramar	0.9	3.5	1.3	1.9
Stick Date: Week 45				
Charm	2.1	3.4	1.9	0.6
Dark Yellow Boaldi	4.6	5.8	6.2	5.7
Miramar	1.2	2.6	2.4	1.1
Stick Date: Week 49				
Charm	1.1	1.8	2.9	3.1
Dark Yellow Boaldi	5.4	5.9	6.3	4.5
Miramar	1.6	2.2	2.6	1.1
Statistical mean	3.0	3.9	3.5	2.7

DROP treatment

A Standard temperature regime (18/18°C)
B DROP weeks 1, 2 and 3 of S.D.
C DROP week 4 of S.D. to marketing
D DROP throughout S.D.

All figures represent mean values of 10 replicate pots per plot.

b. 12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.

Variety	Average number of leaves per pot with minor deterioration relative to treatment				
	E	F	G	H	J
Stick date: Week 41					
Charm	1.3	1.6	2.4	3.1	2.3
Dark Yellow Boaldi	2.9	3.4	7.8	6.1	3.8
Miramar	0.4	2.5	1.9	1.5	2.1
Stick date: Week 45					
Charm	1.3	1.6	2.2	1.0	2.0
Dark Yellow Boaldi	5.5	6.5	6.7	4.8	4.5
Miramar	1.4	1.9	1.6	1.4	0.7
Stick date: Week 49					
Charm	4.1	2.5	4.2	2.4	4.9
Dark Yellow Boaldi	8.6	7.2	5.4	6.0	7.9
Miramar	3.0	2.9	2.3	2.5	2.1
Statistical mean	3.2	3.3	3.8	3.2	3.4

DROP treatment

E Standard temperature regime (18/18°C)
F DROP weeks 1, 2 and 3 of S.D.
G DROP week 4 of S.D. to marketing
H DROP throughout S.D.
J Standard temperature regime (18/18°C) + Daminozide

All figures represent mean values of 10 replicate pots per plot

Table 11: **Effect of DROP treatment and supplementary lighting on leaf quality (assessed at standard marketing stage)**

a. **4.8 W/m² (2000 lux) supplementary lighting throughout S.D.**

Variety	Average number of leaves per pot with moderate deterioration relative to treatment			
	A	B	C	D
Stick Date: Week 41				
Charm	0.2	0.2	0.1	0.0
Dark Yellow Boaldi	0.3	1.3	0.1	0.2
Miramar	0.2	0.4	0.0	0.0
Stick Date: Week 45				
Charm	0.2	0.1	0.0	0.0
Dark Yellow Boaldi	0.3	0.1	0.0	0.1
Miramar	0.0	0.4	0.0	0.0
Stick Date: Week 49				
Charm	0.0	0.0	0.1	0.0
Dark Yellow Boaldi	0.2	0.0	0.2	0.0
Miramar	0.0	0.0	0.0	0.0
Statistical mean	0.2	0.3	0.1	0.1

DROP treatment

A Standard temperature regime (18/18°C)
B DROP weeks 1, 2 and 3 of S.D.
C DROP week 4 of S.D. to marketing
D DROP throughout S.D.

All figures represent mean values of 10 replicate pots per plot.

b. **12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.**

Variety	Average number of leaves per pot with moderate deterioration relative to treatment				
	E	F	G	H	J
Stick date: Week 41					
Charm	0.1	0.2	0.4	0.3	0.0
Dark Yellow Boaldi	0.1	0.3	0.4	1.3	1.6
Miramar	0.1	0.0	0.1	0.5	0.0
Stick date: Week 45					
Charm	0.0	0.7	0.0	0.1	0.2
Dark Yellow Boaldi	1.4	1.4	0.9	0.6	0.2
Miramar	0.0	0.6	0.0	0.2	0.1
Stick date: Week 49					
Charm	0.4	0.6	1.1	0.1	0.9
Dark Yellow Boaldi	0.2	0.2	0.1	0.0	0.0
Miramar	0.0	0.1	0.1	0.0	0.0
Statistical mean	0.3	0.5	0.3	0.3	0.3

DROP treatment

E Standard temperature regime (18/18°C)
F DROP weeks 1, 2 and 3 of S.D.
G DROP week 4 of S.D. to marketing
H DROP throughout S.D.
J Standard temperature regime (18/18°C) + Daminozide

All figures represent mean values of 10 replicate pots per plot

Table 12: Effect of DROP treatment and supplementary lighting on leaf quality (assessed at standard marketing stage)

a. 4.8 W/m² (2000 lux) supplementary lighting throughout S.D.

Variety	Average number of leaves per pot with severe deterioration relative to treatment			
	A	B	C	D
Stick Date: Week 41				
Charm	2.9	4.6	4.8	2.6
Dark Yellow Boaldi	4.4	6.8	1.0	3.4
Miramar	4.0	1.6	1.9	2.6
Stick Date: Week 45				
Charm	0.2	0.1	0.6	1.3
Dark Yellow Boaldi	2.1	0.8	1.6	0.2
Miramar	1.0	1.0	1.6	0.5
Stick Date: Week 49				
Charm	0.2	0.1	0.3	0.0
Dark Yellow Boaldi	2.1	1.5	0.3	0.1
Miramar	0.6	0.6	1.1	0.0
Statistical mean	1.9	1.9	1.5	1.2

DROP treatment

A Standard temperature regime (18/18°C)
B DROP weeks 1, 2 and 3 of S.D.
C DROP week 4 of S.D. to marketing
D DROP throughout S.D.

All figures represent mean values of 10 replicate pots per plot.

b. **12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.**

Variety	Average number of leaves per pot with severe deterioration relative to treatment				
	E	F	G	H	J
Stick date: Week 41					
Charm	0.6	1.7	0.5	2.0	1.3
Dark Yellow Boaldi	1.3	0.9	0.1	1.2	0.8
Miramar	0.7	0.5	0.4	0.2	0.2
Stick date: Week 45					
Charm	0.3	0.6	0.8	0.8	0.1
Dark Yellow Boaldi	0.6	0.4	0.9	0.3	0.7
Miramar	0.5	0.6	0.7	1.0	0.1
Stick date: Week 49					
Charm	0.2	0.9	0.0	0.5	0.5
Dark Yellow Boaldi	2.5	2.1	0.7	0.6	2.1
Miramar	0.4	0.0	0.1	0.4	0.0
Statistical mean	0.8	0.9	0.5	0.8	0.6

DROP treatment

E Standard temperature regime (18/18°C)
F DROP weeks 1, 2 and 3 of S.D.
G DROP week 4 of S.D. to marketing
H DROP throughout S.D.
J Standard temperature regime (18/18°C) + Daminozide

All figures represent mean values of 10 replicate pots per plot

APPENDIX III

OBSERVATION SPACING TRIAL: Interaction of pot spacing with supplementary lighting and DROP

- Tables of Results

Table 1: **Interaction of spacing with DROP and supplementary lighting on plant height (assessed at standard marketing stage)**

a. **4.8 W/m² (2000 lux) supplementary lighting throughout S.D.**

Variety	Average plant height (cm) relative to treatment			
	A	M	D	N
Stick Date: Week 41				
Charm	19.2	19.7	19.4	19.1
Dark Yellow Boaldi	25.5	26.1	25.3	24.5
Miramar	21.4	21.6	20.4	20.5
Stick Date: Week 45				
Charm	23.1	23.3	21.0	21.5
Dark Yellow Boaldi	27.2	26.4	25.0	26.0
Miramar	26.6	25.8	22.1	22.7
Stick Date: Week 49				
Charm	23.3	23.0	21.1	21.0
Dark Yellow Boaldi	30.0	28.7	26.1	25.6
Miramar	25.4	26.7	21.8	23.2
Statistical mean	24.6	24.6	22.5	22.7

Treatments

	Temperature Regime	Spacing
A	Standard (18/18°C)	Standard
M	Standard (18/18°C)	Close
D	DROP throughout S.D.	Standard
N	DROP throughout S.D.	Close

All figures represent mean values of 10 replicate pots per plot

b. **12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.**

Variety	Average plant height (cm) relative to treatment			
	E	O	H	P
Stick Date: Week 41				
Charm	19.4	21.9	17.5	19.3
Dark Yellow Boaldi	26.3	27.2	25.2	24.0
Miramar	20.2	21.5	20.4	20.7
Stick Date: Week 45				
Charm	21.1	22.5	19.4	19.6
Dark Yellow Boaldi	28.4	27.9	24.9	25.1
Miramar	24.4	24.8	21.8	24.0
Stick Date: Week 49				
Charm	22.6	23.2	21.2	21.2
Dark Yellow Boaldi	28.0	27.3	26.4	27.6
Miramar	24.8	24.5	23.6	24.8
Statistical mean	23.9	24.5	22.3	22.9

Treatments

	Temperature Regime	Spacing
E	Standard (18/18°C)	Standard
O	Standard (18/18°C)	Close
H	DROP throughout S.D.	Standard
P	DROP throughout S.D.	Close

All figures represent mean values of 10 replicate pots per plot

Table 2: **Interaction of spacing with DROP and supplementary lighting on variability of plant height (assessed at standard marketing stage)**

a. **4.8 W/m² (2000 lux) supplementary lighting throughout S.D.**

Variety	Average standard deviation of plant height relative to treatment			
	A	M	D	N
Stick Date: Week 41				
Charm	1.1	1.2	1.2	1.3
Dark Yellow Boaldi	1.4	1.9	1.0	1.2
Miramar	1.1	1.2	1.2	1.3
Stick Date: Week 45				
Charm	1.3	1.3	1.3	1.2
Dark Yellow Boaldi	1.2	1.3	1.3	1.1
Miramar	1.3	1.5	1.5	1.1
Stick Date: Week 49				
Charm	1.4	1.7	1.1	1.2
Dark Yellow Boaldi	1.6	1.3	1.4	1.0
Miramar	1.1	1.1	1.2	0.8
Statistical mean	1.3	1.4	1.3	1.1

Treatments

	Temperature Regime	Spacing
A	Standard (18/18°C)	Standard
M	Standard (18/18°C)	Close
D	DROP throughout S.D.	Standard
N	DROP throughout S.D.	Close

All figures represent mean values of 10 replicate pots per plot

b. **12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.**

Variety	Average standard deviation of plant height relative to treatment			
	E	O	H	P
Stick Date: Week 41				
Charm	1.4	1.1	1.0	1.1
Dark Yellow Boaldi	1.5	1.4	1.3	1.3
Miramar	1.2	1.3	1.0	1.4
Stick Date: Week 45				
Charm	1.4	1.7	1.3	1.4
Dark Yellow Boaldi	1.2	1.4	1.4	1.4
Miramar	1.5	1.4	1.1	0.9
Stick Date: Week 49				
Charm	1.4	1.2	1.1	1.2
Dark Yellow Boaldi	1.3	1.3	1.3	1.0
Miramar	1.7	1.2	1.3	1.5
Statistical mean	1.4	1.2	1.2	1.2

Treatments

	Temperature Regime	Spacing
E	Standard (18/18°C)	Standard
O	Standard (18/18°C)	Close
H	DROP throughout S.D.	Standard
P	DROP throughout S.D.	Close

All figures represent mean values of 10 replicate pots per plot

Table 3: **Interaction of spacing with DROP and supplementary lighting on production time (assessed at standard marketing stage)**

a. **4.8 W/m² (2000 lux) supplementary lighting throughout S.D.**

Variety	Average number of days from sticking to marketing relative to treatment			
	A	M	D	N
Stick Date: Week 41				
Charm	78.0	78.0	79.0	78.0
Dark Yellow Boaldi	78.0	78.0	79.0	78.0
Miramar	78.0	78.0	78.0	78.0
Stick Date: Week 45				
Charm	76.8	78.6	76.9	77.4
Dark Yellow Boaldi	78.6	78.7	78.8	82.0
Miramar	81.2	80.4	81.0	81.0
Stick Date: Week 49				
Charm	74.9	75.0	75.7	75.8
Dark Yellow Boaldi	76.6	77.3	77.1	77.1
Miramar	78.3	77.0	79.2	79.3
Statistical mean	77.8	77.9	78.3	78.5

Treatments

	Temperature Regime	Spacing
A	Standard (18/18°C)	Standard
M	Standard (18/18°C)	Close
D	DROP throughout S.D.	Standard
N	DROP throughout S.D.	Close

All figures represent mean values of 10 replicate pots per plot

b. 12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.

Variety	Average number of days from sticking to marketing relative to treatment			
	E	O	H	P
Stick Date: Week 41				
Charm	76.0	76.0	77.0	77.0
Dark Yellow Boaldi	76.0	77.0	77.0	77.0
Miramar	76.0	77.0	77.0	77.0
Stick Date: Week 45				
Charm	71.7	74.3	73.7	74.5
Dark Yellow Boaldi	75.4	75.8	76.5	77.2
Miramar	73.9	75.8	75.1	75.4
Stick Date: Week 49				
Charm	72.2	73.1	72.5	74.3
Dark Yellow Boaldi	75.0	76.0	75.4	77.0
Miramar	73.3	74.9	75.6	76.4
Statistical mean	74.4	75.5	75.5	76.2

Treatments

	Temperature Regime	Spacing
E	Standard (18/18°C)	Standard
O	Standard (18/18°C)	Close
H	DROP throughout S.D.	Standard
P	DROP throughout S.D.	Close

All figures represent mean values of 10 replicate pots per plot

Table 4: **Interaction of spacing with DROP and supplementary lighting on maximum and minimum pot spread (assessed at standard marketing stage)**

a. **4.8 W/m² (2000 lux) supplementary lighting throughout S.D.**

Variety		Average maximum and minimum pot spread (cm) relative to treatment A	M	D	N
Stick date: Week 41					
Charm	Max.	38.7	36.5	36.8	35.7
	Min.	34.9	33.5	34.3	32.8
Dark Yellow Boaldi	Max.	48.8	46.7	43.9	41.2
	Min.	41.0	40.5	39.2	36.3
Miramar	Max.	42.3	38.1	38.2	36.4
	Min.	38.3	33.7	34.3	31.1
Stick date: Week 45					
Charm	Max.	36.6	36.8	34.5	34.1
	Min.	32.4	31.8	31.5	29.2
Dark Yellow Boaldi	Max.	44.5	41.1	43.4	40.1
	Min.	38.5	35.6	37.3	34.5
Miramar	Max.	43.0	43.0	41.2	40.5
	Min.	39.1	37.6	37.9	36.0
Stick date: Week 49					
Charm	Max.	39.3	39.5	39.8	37.9
	Min.	36.0	34.6	35.3	34.9
Dark Yellow Boaldi	Max.	47.2	44.5	43.8	46.0
	Min.	43.4	38.5	41.2	40.9
Miramar	Max.	44.3	42.0	42.7	39.2
	Min.	40.4	38.9	38.2	34.1
Statistical mean	Max.	42.7	40.9	40.5	39.0
	Min.	38.2	36.1	36.6	34.4

Treatments

	Temperature Regime	Spacing
A	Standard (18/18°C)	Standard
M	Standard (18/18°C)	Close
D	DROP throughout S.D.	Standard
N	DROP throughout S.D.	Close

All figures represent mean values of 10 replicate pots per plot

b. **12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.**

Variety		Average maximum and minimum pot spread (cm) relative to treatment E	O	H	P
Stick date: Week 41					
Charm	Max.	37.4	36.0	35.4	34.7
	Min.	34.3	31.8	31.9	30.8
Dark Yellow Boaldi	Max.	46.3	43.2	40.9	39.5
	Min.	40.4	37.8	36.8	34.7
Miramar	Max.	37.8	36.1	35.3	32.6
	Min.	33.9	31.0	32.8	29.0
Stick date: Week 45					
Charm	Max.	35.1	33.7	33.7	32.1
	Min.	31.6	30.5	29.6	28.8
Dark Yellow Boaldi	Max.	43.0	43.2	41.3	38.7
	Min.	37.6	33.4	36.3	33.8
Miramar	Max.	34.7	36.2	36.5	35.2
	Min.	30.8	31.3	32.0	31.1
Stick date: Week 49					
Charm	Max.	38.7	38.2	38.6	36.3
	Min.	35.5	34.5	36.5	33.4
Dark Yellow Boaldi	Max.	49.6	47.0	44.1	45.7
	Min.	42.2	41.2	39.6	41.6
Miramar	Max.	42.1	38.1	39.8	39.8
	Min.	38.8	34.3	37.0	37.2
Statistical mean	Max.	40.5	39.1	38.4	37.1
	Min.	36.1	34.0	34.7	33.4

Treatments

	Temperature Regime	Spacing
E	Standard (18/18°C)	Standard
O	Standard (18/18°C)	Close
H	DROP throughout S.D.	Standard
P	DROP throughout S.D.	Close

All figures represent mean values of 10 replicate pots per plot

Table 5: **Interaction of spacing with DROP and supplementary lighting on bud development (assessed at standard marketing stage)**

a. 4.8 W/m² (2000 lux) supplementary lighting throughout S.D.

Variety	Average number of buds at stages 1 & 2 relative to treatment			
	A	M	D	N
Stick Date: Week 41				
Charm	8.5	10.3	11.7	9.7
Dark Yellow Boaldi	7.4	6.5	6.6	6.9
Miramar	3.3	4.0	2.8	3.3
Stick Date: Week 45				
Charm	14.4	7.6	12.1	11.9
Dark Yellow Boaldi	4.6	3.2	3.2	2.0
Miramar	9.0	7.1	2.3	2.4
Stick Date: Week 49				
Charm	12.0	10.2	15.6	10.1
Dark Yellow Boaldi	3.8	4.2	3.0	4.0
Miramar	6.4	6.9	6.8	2.7
Statistical mean	7.7	6.7	7.1	5.9

Treatments

	Temperature Regime	Spacing
A	Standard (18/18°C)	Standard
M	Standard (18/18°C)	Close
D	DROP throughout S.D.	Standard
N	DROP throughout S.D.	Close

All figures represent mean values of 10 replicate pots per plot

b. 12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.

Variety	Average number of buds at stages 1 & 2 relative to treatment			
	E	O	H	P
Stick Date: Week 41				
Charm	5.4	6.1	6.9	6.6
Dark Yellow Boaldi	7.6	8.8	5.9	6.5
Miramar	5.5	3.9	7.0	4.5
Stick Date: Week 45				
Charm	7.5	5.8	4.0	3.8
Dark Yellow Boaldi	1.7	0.5	0.8	1.3
Miramar	1.0	4.2	2.5	3.5
Stick Date: Week 49				
Charm	5.5	5.1	6.1	5.7
Dark Yellow Boaldi	4.2	0.0	0.5	1.0
Miramar	3.4	3.5	5.9	5.9
Statistical mean	4.6	4.2	4.4	4.3

Treatments

	Temperature Regime	Spacing
E	Standard (18/18°C)	Standard
O	Standard (18/18°C)	Close
H	DROP throughout S.D.	Standard
P	DROP throughout S.D.	Close

All figures represent mean values of 10 replicate pots per plot

Table 6: **Interaction of spacing with DROP and supplementary lighting on bud development (assessed at standard marketing stage)**

a. **4.8 W/m² (2000 lux) supplementary lighting throughout S.D.**

Variety	Average number of buds at stages 3 & 4 relative to treatment			
	A	M	D	N
Stick Date: Week 41				
Charm	15.3	12.9	15.7	14.6
Dark Yellow Boaldi	11.7	16.0	22.0	23.1
Miramar	14.1	13.1	22.4	17.6
Stick Date: Week 45				
Charm	22.8	19.0	13.6	16.2
Dark Yellow Boaldi	23.7	21.9	21.2	18.2
Miramar	19.4	18.5	18.1	16.4
Stick Date: Week 49				
Charm	19.7	14.1	15.8	13.5
Dark Yellow Boaldi	29.8	29.1	28.1	24.5
Miramar	15.9	16.6	11.7	10.9
Statistical mean	19.2	17.9	18.7	17.2

Treatments

	Temperature Regime	Spacing
A	Standard (18/18°C)	Standard
M	Standard (18/18°C)	Close
D	DROP throughout S.D.	Standard
N	DROP throughout S.D.	Close

All figures represent mean values of 10 replicate pots per plot

b. **12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.**

Variety	Average number of buds at stages 3 & 4 relative to treatment			
	E	O	H	P
Stick Date: Week 41				
Charm	7.9	10.6	7.4	7.4
Dark Yellow Boaldi	4.0	1.5	12.4	14.1
Miramar	3.6	3.8	9.1	7.4
Stick Date: Week 45				
Charm	8.4	7.9	6.0	5.8
Dark Yellow Boaldi	7.5	4.9	12.3	9.2
Miramar	6.8	5.1	9.9	9.9
Stick Date: Week 49				
Charm	9.7	10.6	10.9	10.5
Dark Yellow Boaldi	18.5	7.6	17.2	19.6
Miramar	12.2	9.3	15.2	10.8
Statistical mean	8.7	6.8	11.2	10.5

Treatments

	Temperature Regime	Spacing
E	Standard (18/18°C)	Standard
O	Standard (18/18°C)	Close
H	DROP throughout S.D.	Standard
P	DROP throughout S.D.	Close

All figures represent mean values of 10 replicate pots per plot

Table 7: **Interaction of spacing with DROP and supplementary lighting on bud development (assessed at standard marketing stage)**

a. **4.8 W/m² (2000 lux) supplementary lighting throughout S.D.**

Variety	Average number of buds at stage 5 and above relative to treatment			
	A	M	D	N
Stick Date: Week 41				
Charm	25.3	24.6	22.1	21.3
Dark Yellow Boaldi	46.1	32.3	34.3	21.8
Miramar	27.0	20.3	20.0	16.6
Stick Date: Week 45				
Charm	14.9	13.8	15.2	12.7
Dark Yellow Boaldi	30.7	25.3	32.5	27.3
Miramar	16.9	18.8	24.8	23.0
Stick Date: Week 49				
Charm	19.6	20.1	19.4	18.3
Dark Yellow Boaldi	27.4	21.8	29.2	28.4
Miramar	19.7	17.6	20.4	19.0
Statistical mean	25.3	21.6	24.2	20.9

Treatments

	Temperature Regime	Spacing
A	Standard (18/18°C)	Standard
M	Standard (18/18°C)	Close
D	DROP throughout S.D.	Standard
N	DROP throughout S.D.	Close

All figures represent mean values of 10 replicate pots per plot

b. 12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.

Variety	Average number of buds at stage 5 and above relative to treatment E	O	H	P
Stick Date: Week 41				
Charm	24.4	21.2	23.5	20.0
Dark Yellow Boaldi	33.4	32.4	30.5	22.1
Miramar	23.8	18.9	23.2	17.2
Stick Date: Week 45				
Charm	13.4	12.1	15.2	12.1
Dark Yellow Boaldi	27.2	20.1	24.5	20.9
Miramar	13.9	12.3	14.2	13.0
Stick Date: Week 49				
Charm	20.4	17.4	20.9	17.2
Dark Yellow Boaldi	28.9	25.7	31.0	25.9
Miramar	19.5	14.9	17.4	15.1
Statistical mean	22.8	19.4	22.3	18.2

Treatments

	Temperature Regime	Spacing
E	Standard (18/18°C)	Standard
O	Standard (18/18°C)	Close
H	DROP throughout S.D.	Standard
P	DROP throughout S.D.	Close

All figures represent mean values of 10 replicate pots per plot

Table 8: **Interaction of spacing with DROP and supplementary lighting on total bud count (assessed at standard marketing stage)**

a. **4.8 W/m² (2000 lux) supplementary lighting throughout S.D.**

Variety	Average total number of buds relative to treatment			
	A	M	D	N
Stick Date: Week 41				
Charm	49.1	47.8	49.5	45.6
Dark Yellow Boaldi	65.2	54.8	62.9	51.8
Miramar	44.4	37.4	45.2	37.5
Stick Date: Week 45				
Charm	52.1	40.4	40.9	40.8
Dark Yellow Boaldi	59.0	50.4	56.9	47.5
Miramar	45.3	44.4	45.2	41.8
Stick Date: Week 49				
Charm	51.3	44.4	50.8	41.9
Dark Yellow Boaldi	61.0	55.1	60.3	56.9
Miramar	42.0	41.1	38.9	32.6
Statistical mean	52.2	46.2	50.1	44.0

Treatments

	Temperature Regime	Spacing
A	Standard (18/18°C)	Standard
M	Standard (18/18°C)	Close
D	DROP throughout S.D.	Standard
N	DROP throughout S.D.	Close

All figures represent mean values of 10 replicate pots per plot

b. **12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.**

Variety	Average total number of buds relative to treatment			
	E	O	H	P
Stick Date: Week 41				
Charm	37.7	37.9	37.8	34.0
Dark Yellow Boaldi	45.0	42.7	48.8	42.7
Miramar	32.9	26.6	39.3	29.1
Stick Date: Week 45				
Charm	29.3	25.8	25.2	21.7
Dark Yellow Boaldi	36.4	25.5	37.6	31.4
Miramar	21.7	21.6	26.6	26.4
Stick Date: Week 49				
Charm	35.6	33.1	37.9	33.4
Dark Yellow Boaldi	51.6	33.3	48.7	46.5
Miramar	35.1	27.7	38.5	31.8
Statistical mean	36.1	30.5	37.8	33.0

Treatments

	Temperature Regime	Spacing
E	Standard (18/18°C)	Standard
O	Standard (18/18°C)	Close
H	DROP throughout S.D.	Standard
P	DROP throughout S.D.	Close

All figures represent mean values of 10 replicate pots per plot

Table 9: **Interaction of spacing with DROP and supplementary lighting on uniformity of flowering (assessed at standard marketing stage)**

a. **4.8 W/m² (2000 lux) supplementary lighting throughout S.D.**

Variety	Average maximum bud stage* relative to treatment			
	A	M	D	N
Stick Date: Week 41				
Charm	9.0	8.9	8.8	8.8
Dark Yellow Boaldi	8.7	7.9	8.1	6.6
Miramar	7.8	7.8	7.6	6.9
Stick Date: Week 45				
Charm	8.4	8.1	8.5	8.2
Dark Yellow Boaldi	7.6	7.6	7.9	7.3
Miramar	7.6	7.8	8.0	7.9
Stick Date: Week 49				
Charm	8.8	8.6	8.9	8.9
Dark Yellow Boaldi	7.3	7.3	7.6	7.7
Miramar	7.9	7.6	7.8	7.7
Statistical mean	8.1	8.0	8.1	7.8

Treatments

	Temperature Regime	Spacing
A	Standard (18/18°C)	Standard
M	Standard (18/18°C)	Close
D	DROP throughout S.D.	Standard
N	DROP throughout S.D.	Close

* As defined by Cockshull and Hughes (1972)

All figures represent mean values of 10 replicate pots per plot

b. **12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.**

Variety	Average maximum bud stage* relative to treatment			
	E	O	H	P
Stick Date: Week 41				
Charm	9.0	8.9	8.9	8.9
Dark Yellow Boaldi	7.9	8.2	7.9	6.5
Miramar	8.0	8.0	8.0	7.5
Stick Date: Week 45				
Charm	8.5	8.3	8.7	8.7
Dark Yellow Boaldi	7.9	7.5	7.9	7.6
Miramar	7.9	7.6	8.0	7.7
Stick Date: Week 49				
Charm	9.0	8.9	9.0	8.6
Dark Yellow Boaldi	7.8	7.7	7.9	7.4
Miramar	8.0	7.9	7.9	7.7
Statistical mean	8.2	8.1	8.3	7.9

Treatments

	Temperature Regime	Spacing
E	Standard (18/18°C)	Standard
O	Standard (18/18°C)	Close
H	DROP throughout S.D.	Standard
P	DROP throughout S.D.	Close

* As defined by Cockshull and Highes (1972)

All figures represent mean values of 10 replicate pots per plot

Table 10: **Interaction of spacing with DROP and supplementary lighting on leaf quality (assessed at standard marketing stage)**

a. **4.8 W/m² (2000 lux) supplementary lighting throughout S.D.**

Variety	Average number of leaves per pot with minor deterioration relative to treatment			
	A	M	D	N
Stick Date: Week 41				
Charm	2.4	1.6	1.7	1.7
Dark Yellow Boaldi	7.4	5.5	4.4	4.5
Miramar	0.9	1.7	1.9	1.3
Stick Date: Week 45				
Charm	2.1	0.8	0.6	0.9
Dark Yellow Boaldi	4.6	3.9	5.7	7.1
Miramar	1.2	1.0	1.1	1.3
Stick Date: Week 49				
Charm	1.1	1.5	3.1	1.1
Dark Yellow Boaldi	5.4	5.9	4.5	3.4
Miramar	1.6	1.8	1.1	0.9
Statistical mean	3.0	2.6	2.7	2.5

Treatments

	Temperature Regime	Spacing
A	Standard (18/18°C)	Standard
M	Standard (18/18°C)	Close
D	DROP throughout S.D.	Standard
N	DROP throughout S.D.	Close

All figures represent mean values of 10 replicate pots per plot

b. **12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.**

Variety	Average number of leaves per pot with minor deterioration relative to treatment			
	E	O	H	P
Stick Date: Week 41				
Charm	1.3	0.8	3.1	1.7
Dark Yellow Boaldi	2.9	6.8	6.1	5.4
Miramar	0.4	3.1	1.5	2.3
Stick Date: Week 45				
Charm	1.3	0.5	1.0	0.6
Dark Yellow Boaldi	5.5	4.9	4.8	7.2
Miramar	1.4	1.3	1.4	1.2
Stick Date: Week 49				
Charm	4.1	2.6	2.4	2.1
Dark Yellow Boaldi	8.6	6.5	6.0	6.0
Miramar	3.0	1.9	2.5	1.9
Statistical mean	3.2	3.2	3.2	3.2

Treatments

	Temperature Regime	Spacing
E	Standard (18/18°C)	Standard
O	Standard (18/18°C)	Close
H	DROP throughout S.D.	Standard
P	DROP throughout S.D.	Close

All figures represent mean values of 10 replicate pots per plot

Table 11: **Interaction of spacing with DROP and supplementary lighting on leaf quality (assessed at standard marketing stage)**

a. **4.8 W/m² (2000 lux) supplementary lighting throughout S.D.**

Variety	Average number of leaves per pot with moderate deterioration relative to treatment			
	A	M	D	N
Stick Date: Week 41				
Charm	0.2	0.0	0.0	0.2
Dark Yellow Boaldi	0.3	0.9	0.2	0.9
Miramar	0.2	0.2	0.0	0.8
Stick Date: Week 45				
Charm	0.2	0.1	0.0	0.0
Dark Yellow Boaldi	0.3	0.4	0.1	0.5
Miramar	0.0	0.0	0.0	0.2
Stick Date: Week 49				
Charm	0.0	0.0	0.0	0.0
Dark Yellow Boaldi	0.2	0.2	0.0	0.0
Miramar	0.0	0.0	0.0	0.0
Statistical mean	0.2	0.2	0.0	0.3

Treatments

	Temperature Regime	Spacing
A	Standard (18/18°C)	Standard
M	Standard (18/18°C)	Close
D	DROP throughout S.D.	Standard
N	DROP throughout S.D.	Close

All figures represent mean values of 10 replicate pots per plot

b. 12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.

Variety	Average number of leaves per pot with moderate deterioration relative to treatment			
	E	O	H	P
Stick Date: Week 41				
Charm	0.1	0.0	0.3	0.5
Dark Yellow Boaldi	0.1	3.5	1.3	1.7
Miramar	0.1	0.7	0.5	0.3
Stick Date: Week 45				
Charm	0.0	0.2	0.1	0.2
Dark Yellow Boaldi	1.4	2.1	0.6	0.5
Miramar	0.0	0.0	0.2	0.1
Stick Date: Week 49				
Charm	0.4	0.2	0.1	0.1
Dark Yellow Boaldi	0.2	0.0	0.0	0.1
Miramar	0.0	0.0	0.0	0.0
Statistical mean	0.3	0.7	0.3	0.4

Treatments

	Temperature Regime	Spacing
E	Standard (18/18°C)	Standard
O	Standard (18/18°C)	Close
H	DROP throughout S.D.	Standard
P	DROP throughout S.D.	Close

All figures represent mean values of 10 replicate pots per plot

Table 12: **Interaction of spacing with DROP and supplementary lighting on leaf quality (assessed at standard marketing stage)**

a. **4.8 W/m² (2000 lux) supplementary lighting throughout S.D.**

Variety	Average number of leaves per pot with severe deterioration relative to treatment			
	A	M	D	N
Stick Date: Week 41				
Charm	2.9	4.6	2.6	1.9
Dark Yellow Boaldi	4.4	7.3	3.4	3.3
Miramar	4.0	4.0	2.6	2.0
Stick Date: Week 45				
Charm	0.2	1.8	1.3	0.0
Dark Yellow Boaldi	2.1	2.5	0.2	2.7
Miramar	1.0	1.4	0.5	0.5
Stick Date: Week 49				
Charm	0.2	0.0	0.0	0.2
Dark Yellow Boaldi	2.1	2.3	0.1	0.3
Miramar	0.6	0.8	0.0	1.2
Statistical mean	1.9	2.7	1.2	1.3

Treatments

	Temperature Regime	Spacing
A	Standard (18/18°C)	Standard
M	Standard (18/18°C)	Close
D	DROP throughout S.D.	Standard
N	DROP throughout S.D.	Close

All figures represent mean values of 10 replicate pots per plot

b. 12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.

Variety	Average number of leaves with severe deterioration per pot relative to treatment			
	E	O	H	P
Stick Date: Week 41				
Charm	0.6	2.7	2.0	2.5
Dark Yellow Boaldi	1.3	1.2	1.2	2.3
Miramar	0.7	1.1	0.2	1.2
Stick Date: Week 45				
Charm	0.3	1.7	0.8	1.3
Dark Yellow Boaldi	0.6	1.1	0.3	0.6
Miramar	0.5	0.1	1.0	2.0
Stick Date: Week 49				
Charm	0.2	0.6	0.5	0.0
Dark Yellow Boaldi	2.5	3.3	0.6	2.8
Miramar	0.4	1.4	0.4	1.0
Statistical mean	0.8	1.5	0.8	1.5

Treatments

	Temperature Regime	Spacing
E	Standard (18/18°C)	Standard
O	Standard (18/18°C)	Close
H	DROP throughout S.D.	Standard
P	DROP throughout S.D.	Close

All figures represent mean values of 10 replicate pots per plot

APPENDIX IV

OBSERVATION NUTRITION TRIAL: Influence of nutrition and its interaction with supplementary lighting regimes on plant performance at marketing and under shelf-life conditions

- Tables and Figures of Results

Table 1: Effect of nutrition treatment on plant height (assessed at standard marketing stage)

Variety	Average plant height (cm) relative to treatment					
	T	V	W	X	Y	Z
Stick date: Week 41						
Charm	20.4	18.3	18.9	17.6	15.9	17.4
Dark Yellow Boaldi	26.0	24.6	25.4	20.6	21.7	20.9
Stick date: Week 45						
Charm	21.9	21.8	21.8	16.4	17.4	17.3
Dark Yellow Boaldi	26.4	26.1	24.7	20.6	19.5	20.0
Stick date: Week 49						
Charm	23.2	21.8	23.5	18.8	18.5	18.8
Dark Yellow Boaldi	25.6	28.7	28.4	21.3	19.6	22.6
Statistical mean	23.9	23.5	23.8	19.2	18.8	19.5

Nutrition treatments

T	Low feed	} 4.8 W/m² (2000 lux) supplementary lighting throughout S.D.
V	Standard feed	}
W	High feed	}
X	Low feed	} 12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.
Y	Standard feed	}
Z	High feed	}

All figures represent mean values of 10 replicate pots per plot

Table 2: **Effect of nutrition treatment on variability of plant height (assessed at standard marketing stage)**

Variety	Average standard deviation of plant height relative to treatment					
	T	V	W	X	Y	Z
Stick date: Week 41						
Charm	1.2	1.1	1.0	0.9	1.3	1.2
Dark Yellow Boaldi	1.2	1.3	2.0	2.2	2.0	1.6
Stick date: Week 45						
Charm	1.2	1.3	0.9	1.2	1.1	1.4
Dark Yellow Boaldi	1.2	1.2	0.9	1.4	2.0	2.5
Stick date: Week 49						
Charm	1.4	1.2	1.6	1.5	1.5	1.5
Dark Yellow Boaldi	1.5	1.3	1.2	1.6	2.0	1.6
Statistical mean	1.3	1.2	1.3	1.5	1.6	1.6

Nutrition treatments

T	Low feed	4.8 W/m² (2000 lux) supplementary lighting throughout S.D.
V	Standard feed	
W	High feed	
X	Low feed	12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.
Y	Standard feed	
Z	High feed	

All figures represent mean values of 10 replicate pots per plot

Table 3: **Effect of nutrition treatment on production time (assessed at standard marketing stage)**

Variety	Average number of days from sticking to marketing relative to treatment					
	T	V	W	X	Y	Z
Stick date: Week 41						
Charm	68.0	68.0	68.0	68.0	69.0	68.0
Dark Yellow Boaldi	68.0	69.0	69.0	69.0	68.0	68.0
Stick date: Week 45						
Charm	72.0	72.0	72.0	69.0	69.0	69.0
Dark Yellow Boaldi	74.8	75.0	72.0	69.0	69.0	69.0
Stick date: Week 49						
Charm	71.0	71.0	71.0	69.0	69.0	69.0
Dark Yellow Boaldi	71.0	71.0	70.0	69.0	69.0	77.4
Statistical mean	70.8	71.0	70.3	68.8	68.8	70.1

Nutrition treatments

T	Low feed	}
V	Standard feed	} 4.8 W/m² (2000 lux) supplementary lighting throughout S.D.
W	High feed	}
X	Low feed	}
Y	Standard feed	} 12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.
Z	High feed	}

All figures represent mean values of 10 replicate pots per plot

Table 4: **Effect of nutrition treatment on maximum and minimum pot spread (assessed at standard marketing stage)**

Variety		Average plant spread (cm) relative to treatment					
		T	V	W	X	Y	Z
Stick date: Week 41							
Charm	Max.	35.0	34.6	34.0	33.0	31.2	33.0
	Min.	32.6	32.0	32.0	31.2	30.4	29.2
Dark Yellow Boaldi	Max.	41.2	43.0	41.4	37.6	36.0	36.8
	Min.	36.6	37.4	36.6	33.6	33.8	33.6
Stick date: Week 45							
Charm	Max.	34.4	33.8	35.2	30.4	33.0	30.6
	Min.	32.2	31.4	32.0	27.8	28.6	27.8
Dark Yellow Boaldi	Max.	43.0	40.4	38.4	35.2	38.0	35.0
	Min.	37.4	35.8	32.0	31.6	32.0	31.4
Stick date: Week 49							
Charm	Max.	38.0	36.8	38.6	34.4	34.8	34.2
	Min.	35.0	33.8	35.0	31.0	31.2	31.6
Dark Yellow Boaldi	Max.	41.2	45.8	45.8	40.4	40.6	44.0
	Min.	35.8	38.6	39.0	39.0	35.0	39.2
Statistical mean	Max.	38.8	39.1	38.9	35.2	35.6	35.6
	Min.	34.9	34.8	34.4	32.4	31.8	32.1

Nutrition treatments

T	Low feed	} 4.8 W/m² (2000 lux) supplementary lighting throughout S.D.
V	Standard feed	}
W	High feed	}
X	Low feed	} 12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.
Y	Standard feed	}
Z	High feed	}

All figures represent mean values of 10 replicate pots per plot

Table 5: **Effect of nutrition treatment on bud development (assessed at standard marketing stage)**

Variety	Average number of buds at stages 1 and 2 relative to treatment					
	T	V	W	X	Y	Z
Stick date: Week 41						
Charm	22.2	18.2	23.0	19.8	15.8	18.2
Dark Yellow Boaldi	24.2	16.0	16.8	13.4	18.0	17.0
Stick date: Week 45						
Charm	25.0	28.0	16.4	11.0	8.6	10.8
Dark Yellow Boaldi	14.4	22.6	12.2	4.0	4.2	6.8
Stick date: Week 49						
Charm	21.4	19.2	19.4	19.6	18.8	18.8
Dark Yellow Boaldi	21.8	13.2	20.2	10.6	11.2	10.6
Statistical mean	21.5	19.5	18.0	13.1	12.8	13.7

Nutrition treatments

T	Low feed	} 4.8 W/m² (2000 lux) supplementary lighting throughout S.D.
V	Standard feed	}
W	High feed	}
X	Low feed	} 12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.
Y	Standard feed	}
Z	High feed	}

All figures represent mean values of 10 replicate pots per plot

Table 6: **Effect of nutrition treatment on bud development (assessed at standard marketing stage)**

Variety	Average number of buds at stages 3 and 4 relative to treatment					
	T	V	W	X	Y	Z
Stick date: Week 41						
Charm	30.4	25.0	25.8	18.8	18.6	17.4
Dark Yellow Boaldi	32.2	33.8	32.0	20.8	20.8	23.2
Stick date: Week 45						
Charm	18.6	21.4	22.0	12.6	15.4	15.6
Dark Yellow Boaldi	38.6	31.8	30.2	17.2	19.4	26.2
Stick date: Week 49						
Charm	21.0	22.8	20.0	17.4	14.2	18.2
Dark Yellow Boaldi	27.8	36.4	31.8	31.2	25.2	33.2
Statistical mean	28.1	28.5	27.0	19.7	18.9	22.3

Nutrition treatments

T	Low feed	} 4.8 W/m² (2000 lux) supplementary lighting throughout S.D.
V	Standard feed	
W	High feed	
X	Low feed	} 12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.
Y	Standard feed	
Z	High feed	

All figures represent mean values of 10 replicate pots per plot

Table 7: **Effect of nutrition treatment on bud development (assessed at standard marketing stage)**

Variety	Average number of buds at stages 5 and above relative to treatment					
	T	V	W	X	Y	Z
Stick date: Week 41						
Charm	9.0	12.2	10.6	11.0	10.2	8.0
Dark Yellow Boaldi	8.2	12.0	7.8	13.6	11.8	9.6
Stick date: Week 45						
Charm	6.0	6.6	6.6	6.4	7.6	10.2
Dark Yellow Boaldi	13.2	8.6	11.8	10.0	10.4	8.8
Stick date: Week 49						
Charm	9.2	9.8	7.8	7.0	6.8	8.6
Dark Yellow Boaldi	10.6	13.2	12.0	10.0	12.6	15.0
Statistical mean	9.4	10.4	9.4	9.7	9.9	10.0

Nutrition treatments

T	Low feed	}
V	Standard feed	} 4.8 W/m² (2000 lux) supplementary lighting throughout S.D.
W	High feed	}
X	Low feed	}
Y	Standard feed	} 12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.
Z	High feed	}

All figures represent mean values of 10 replicate pots per plot

Table 8: **Effect of nutrition treatment on total bud count (assessed at standard marketing stage)**

Variety	Average total bud count relative to treatment					
	T	V	W	X	Y	Z
Stick date: Week 41						
Charm	61.6	55.4	59.4	49.6	44.6	43.6
Dark Yellow Boaldi	64.6	61.8	56.6	47.8	50.6	49.8
Stick date: Week 45						
Charm	49.6	56.0	45.0	30.0	31.6	36.6
Dark Yellow Boaldi	66.2	63.0	54.2	31.2	34.0	41.8
Stick date: Week 49						
Charm	51.6	51.8	47.2	44.0	39.8	45.6
Dark Yellow Boaldi	60.2	62.8	64.0	51.8	49.0	58.8
Statistical mean	59.0	58.5	54.4	42.4	41.6	46.0

Nutrition treatments

T	Low feed	}
V	Standard feed	} 4.8 W/m² (2000 lux) supplementary lighting throughout S.D.
W	High feed	}
X	Low feed	}
Y	Standard feed	} 12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.
Z	High feed	}

All figures represent mean values of 10 replicate pots per plot

Table 9: **Effect of nutrition treatment on uniformity of flowering (assessed at standard marketing stage)**

Variety	Average maximum bud stage* per plant relative to treatment					
	T	V	W	X	Y	Z
Stick date: Week 41						
Charm	5.7	5.9	5.4	6.1	5.8	5.4
Dark Yellow Boaldi	5.0	5.2	4.8	5.2	5.2	5.0
Stick date: Week 45						
Charm	5.4	5.8	5.9	5.8	6.0	6.7
Dark Yellow Boaldi	6.3	5.2	5.5	5.6	5.5	5.1
Stick date: Week 49						
Charm	6.0	5.9	5.8	5.3	5.3	6.1
Dark Yellow Boaldi	5.7	5.5	5.4	5.6	5.6	5.8
Statistical mean	5.7	5.6	5.5	5.6	5.6	5.7

Nutrition treatments

T	Low feed	}
V	Standard feed	} 4.8 W/m² (2000 lux) supplementary lighting throughout S.D.
W	High feed	}
X	Low feed	}
Y	Standard feed	} 12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.
Z	High feed	}

* As defined by Cockshull and Hughes (1972)

All figures represent mean values of 10 replicate pots per plot

Table 10: Effect of nutrition treatment on leaf quality (assessed at standard marketing stage)

Variety	Average number of leaves per pot with minor deterioration relative to treatment					
	T	V	W	X	Y	Z
Stick date: Week 41						
Charm	0.6	1.6	1.2	1.6	0.6	1.4
Dark Yellow Boaldi	2.8	1.6	1.6	2.4	4.4	1.6
Stick date: Week 45						
Charm	1.2	1.8	2.4	1.6	1.0	3.2
Dark Yellow Boaldi	2.8	3.0	5.4	5.4	4.4	5.0
Stick date: Week 49						
Charm	5.0	5.0	3.0	5.0	6.6	6.3
Dark Yellow Boaldi	12.8	11.0	8.2	13.4	10.8	13.0
Statistical mean	4.2	4.0	3.6	4.9	4.6	5.1

Nutrition treatments

T	Low feed	} 4.8 W/m² (2000 lux) supplementary lighting throughout S.D.
V	Standard feed	}
W	High feed	}
X	Low feed	} 12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.
Y	Standard feed	}
Z	High feed	}

All figures represent mean values of 10 replicate pots per plot

Table 11: Effect of nutrition treatment on leaf quality (assessed at standard marketing stage)

Variety	Average number of leaves per pot with moderate deterioration relative to treatment					
	T	V	W	X	Y	Z
Stick date: Week 41						
Charm	0.0	0.0	0.0	0.0	0.0	0.0
Dark Yellow Boaldi	0.2	1.4	0.4	0.0	0.0	0.0
Stick date: Week 45						
Charm	0.2	0.0	0.0	0.0	0.2	0.0
Dark Yellow Boaldi	0.2	0.6	0.6	1.0	0.4	0.4
Stick date: Week 49						
Charm	0.2	0.0	0.0	0.2	1.2	0.2
Dark Yellow Boaldi	0.2	0.0	0.0	0.0	0.0	0.0
Statistical mean	0.2	0.3	0.2	0.2	0.3	0.1

Nutrition treatments

T	Low feed	} 4.8 W/m² (2000 lux) supplementary lighting throughout S.D.
V	Standard feed	
W	High feed	
X	Low feed	} 12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.
Y	Standard feed	
Z	High feed	

All figures represent mean values of 10 replicate pots per plot

Table 12: **Effect of nutrition treatment on leaf quality (assessed at standard marketing stage)**

Variety	Average number of leaves per pot with severe deterioration relative to treatment					
	T	V	W	X	Y	Z
Stick date: Week 41						
Charm	1.2	0.8	2.0	0.2	1.0	1.2
Dark Yellow Boaldi	0.4	2.4	1.0	0.0	0.0	0.6
Stick date: Week 45						
Charm	0.2	0.2	0.2	0.0	0.2	0.0
Dark Yellow Boaldi	0.6	2.4	0.0	0.2	1.4	0.2
Stick date: Week 49						
Charm	0.0	0.0	0.4	0.2	0.8	0.0
Dark Yellow Boaldi	1.4	1.4	0.2	0.0	0.0	0.2
Statistical mean	0.6	1.2	0.6	0.1	0.6	0.4

Nutrition treatments

T	Low feed	}
V	Standard feed	} 4.8 W/m² (2000 lux) supplementary lighting throughout S.D.
W	High feed	}
X	Low feed	}
Y	Standard feed	} 12 W/m² (5000 lux) supplementary lighting weeks 1, 2 and 3 S.D.
Z	High feed	}

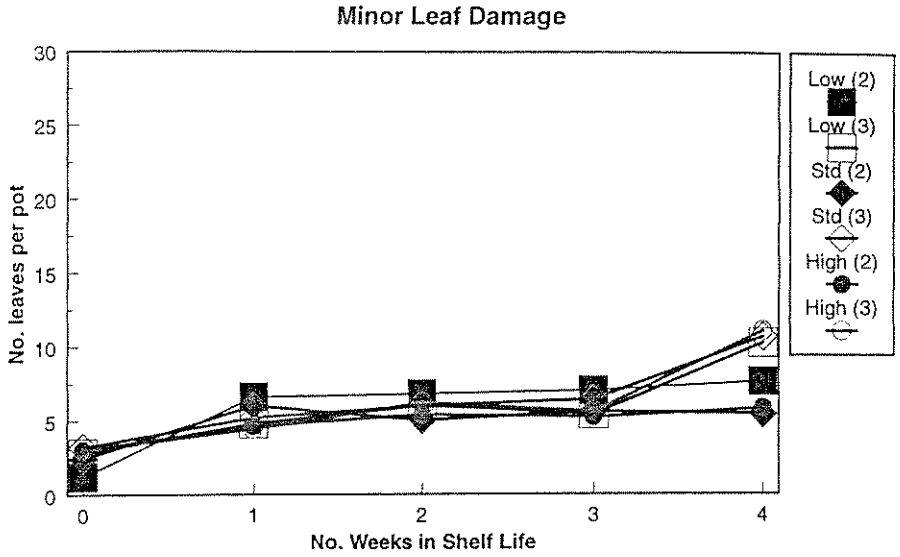
All figures represent mean values of 10 replicate pots per plot

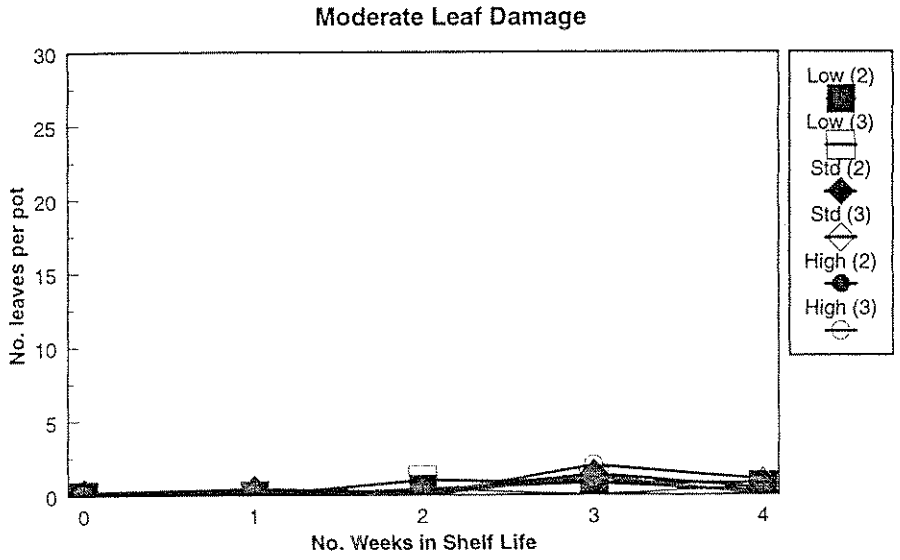
Key to Figures 1-24

Low (2)	=	Low feed treatment, selected for shelf-life simulation at marketing stage 2
Low (3)	=	Low feed treatment, selected for shelf-life simulation at marketing stage 3
Std (2)	=	Standard feed treatment, selected for shelf-life simulation at marketing stage 2
Std (3)	=	Standard feed treatment, selected for shelf-life simulation at marketing stage 3
High (2)	=	High feed treatment, selected for shelf-life simulation at marketing stage 2
High (3)	=	High feed treatment, selected for shelf-life simulation at marketing stage 3

Figure 1

Leaf Quality in Shelf Life - Charm - Stick Week 41
4.8 W/m^2(2000 lux) Supplementary Lighting





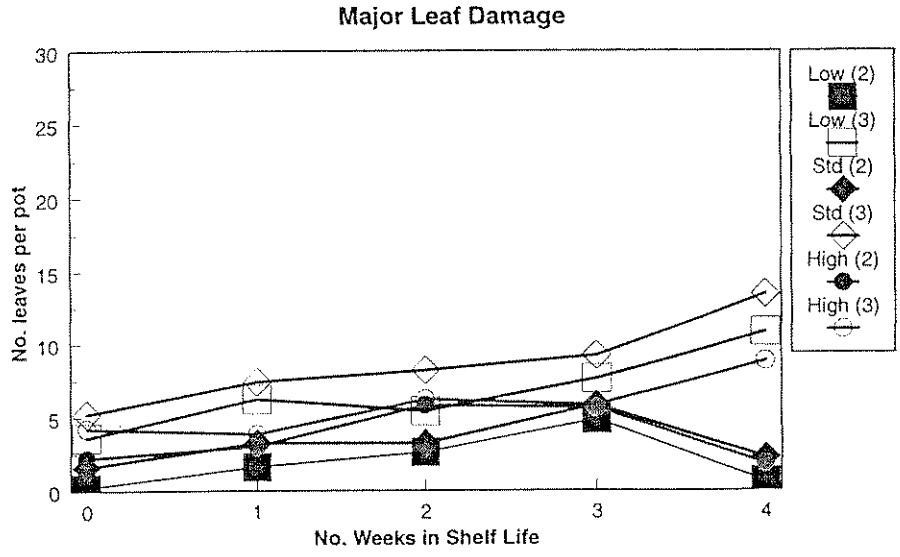


Figure 2
Leaf Quality in Shelf Life - Charm - Stick Week 41
12 W/m^2(5000 lux) Supplementary Lighting

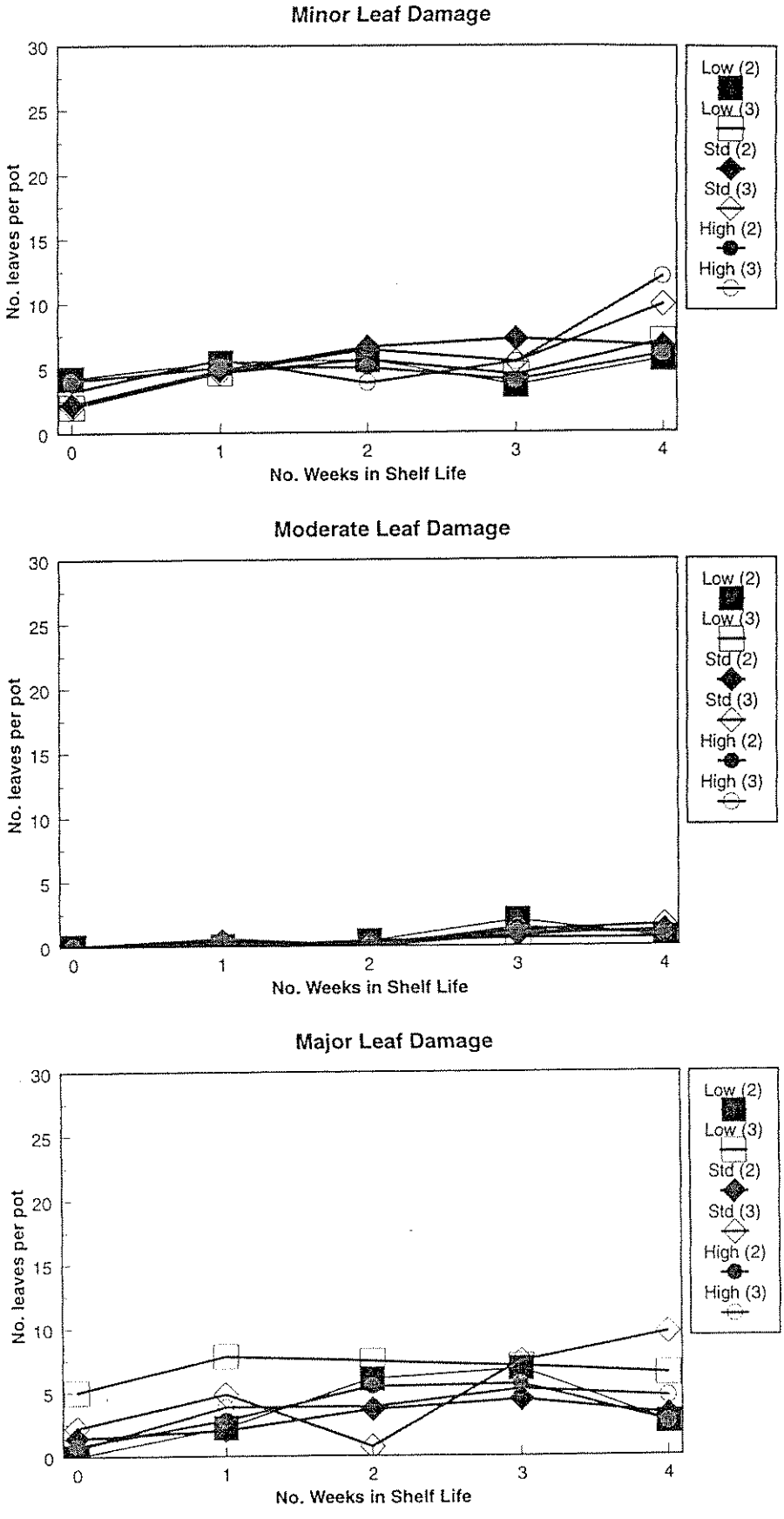


Figure 3

Leaf Quality in Shelf Life - Charm - Stick Week 45
4.8 W/m^2(2000 lux) Supplementary Lighting

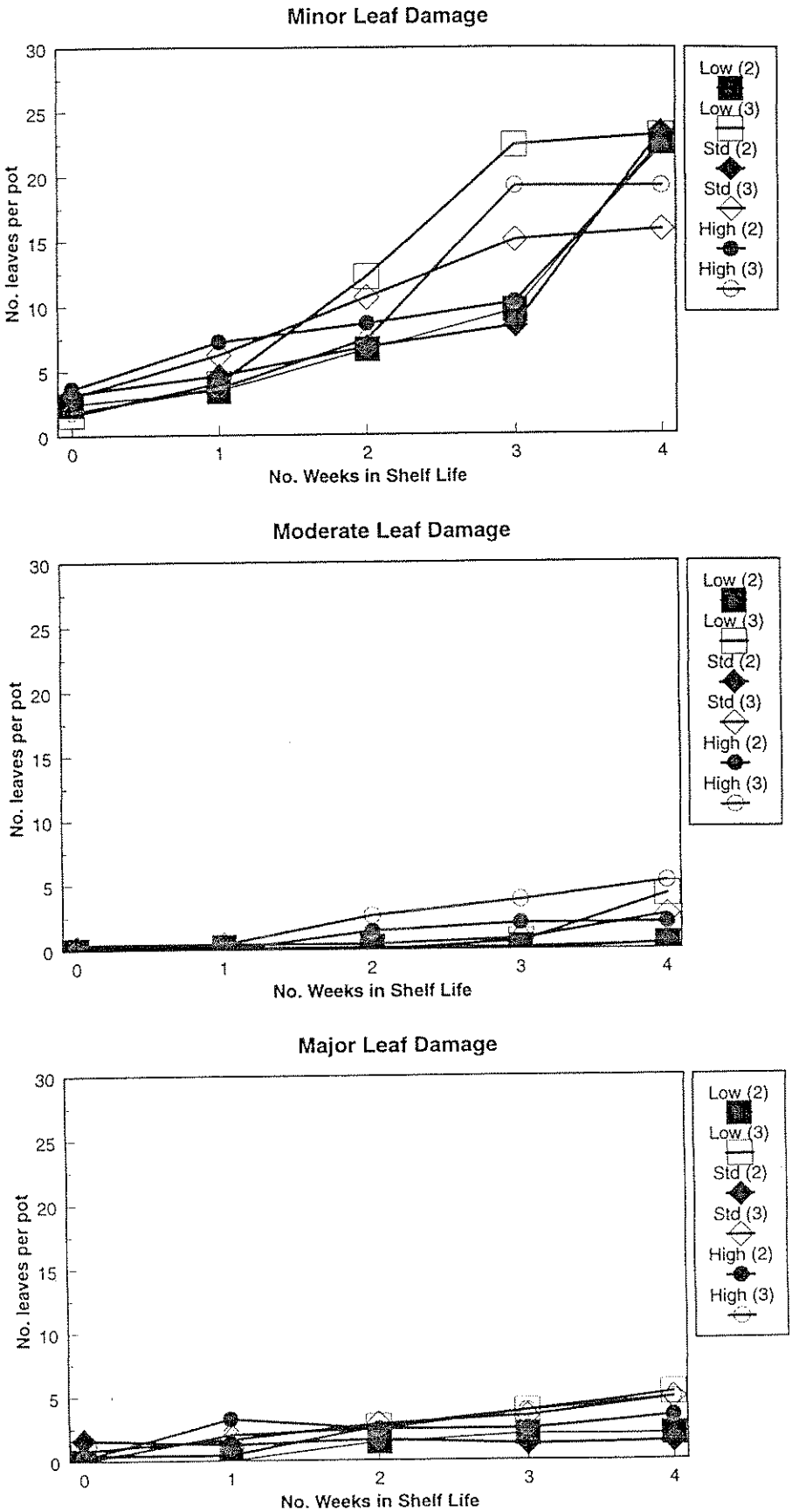


Figure 4

Leaf Quality in Shelf Life - Charm - Stick Week 45
12 W/m^2(5000 lux) Supplementary Lighting

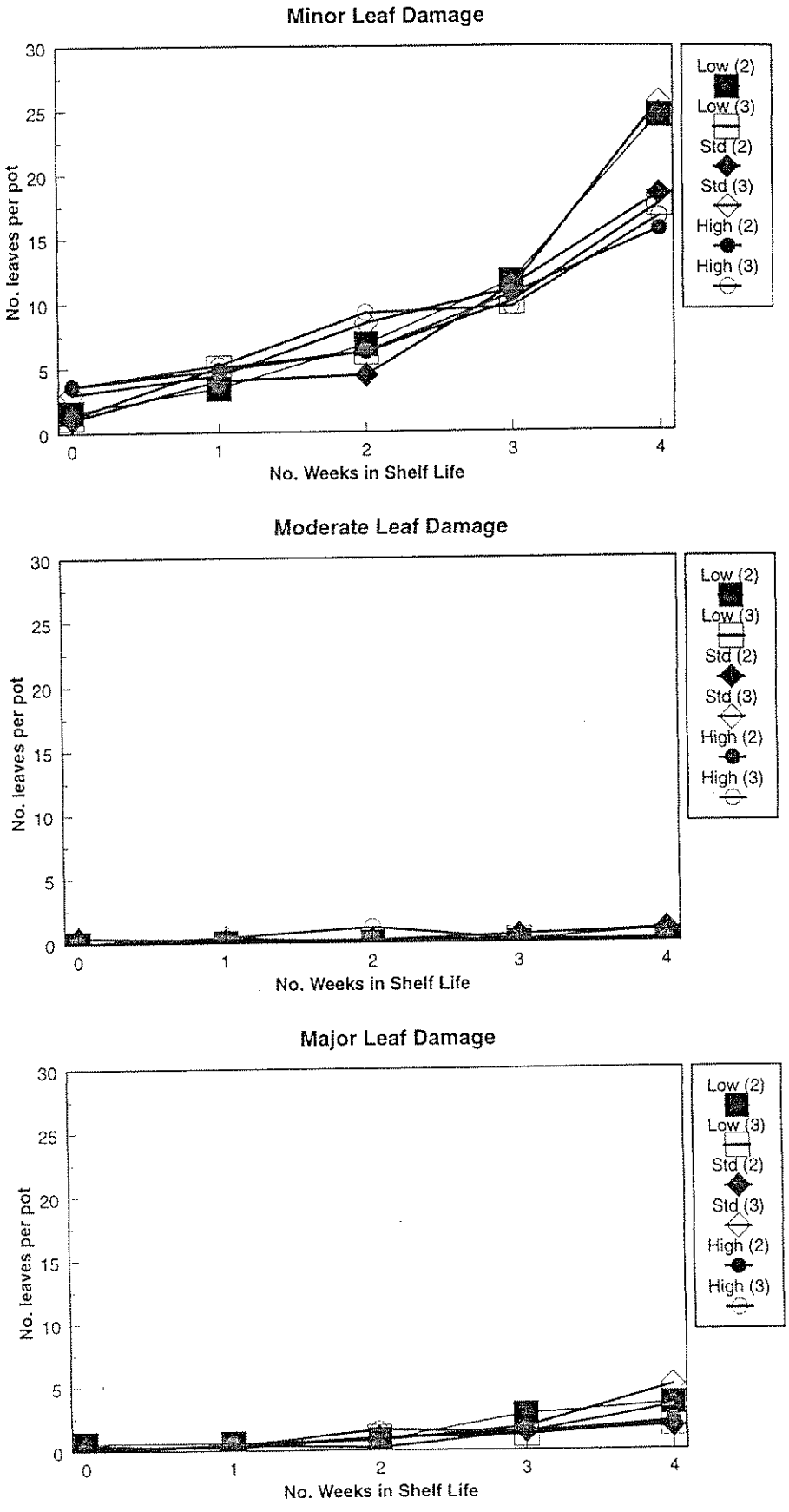


Figure 5
Leaf Quality in Shelf Life - Charm - Stick Week 49
4.8 W/m^2(2000 lux) Supplementary Lighting

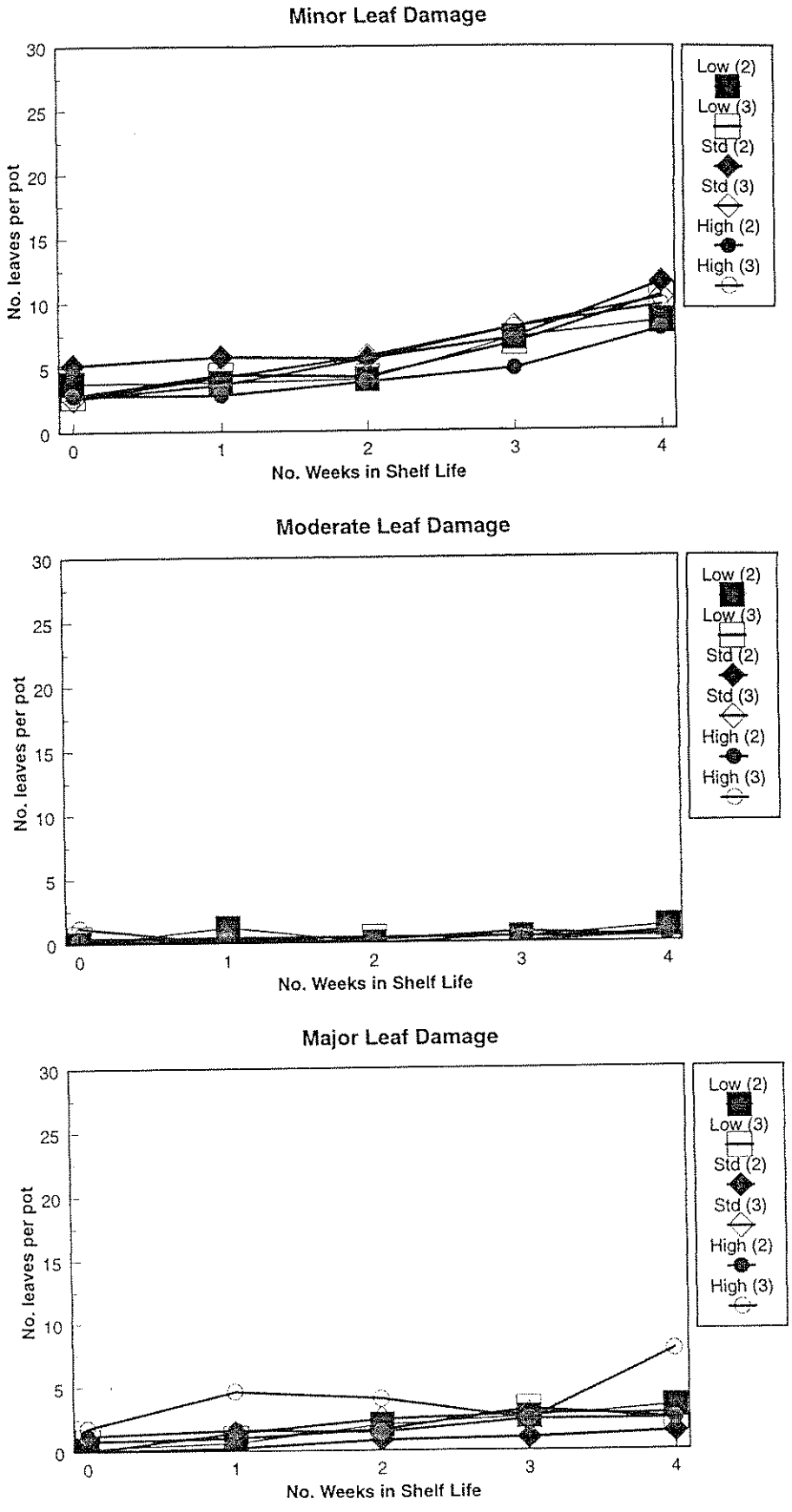


Figure 6

Leaf Quality in Shelf Life - Charm - Stick Week 49

12 W/m^2(5000 lux) Supplementary Lighting

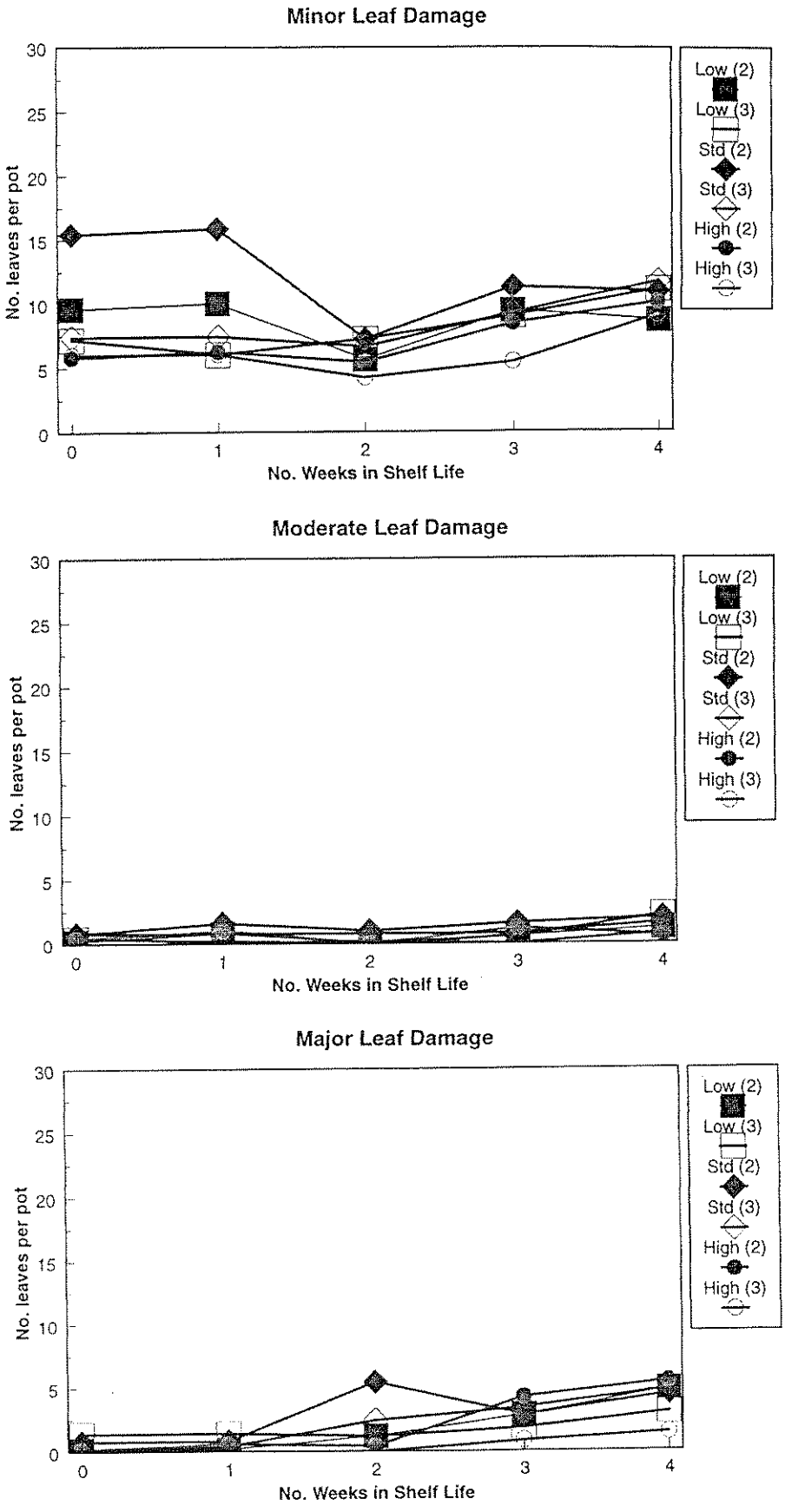


Figure 7

Leaf Quality in Shelf Life - Dark Yellow Boaldi - Stick Week 41
4.8 W/m^2(2000 lux) Supplementary Lighting

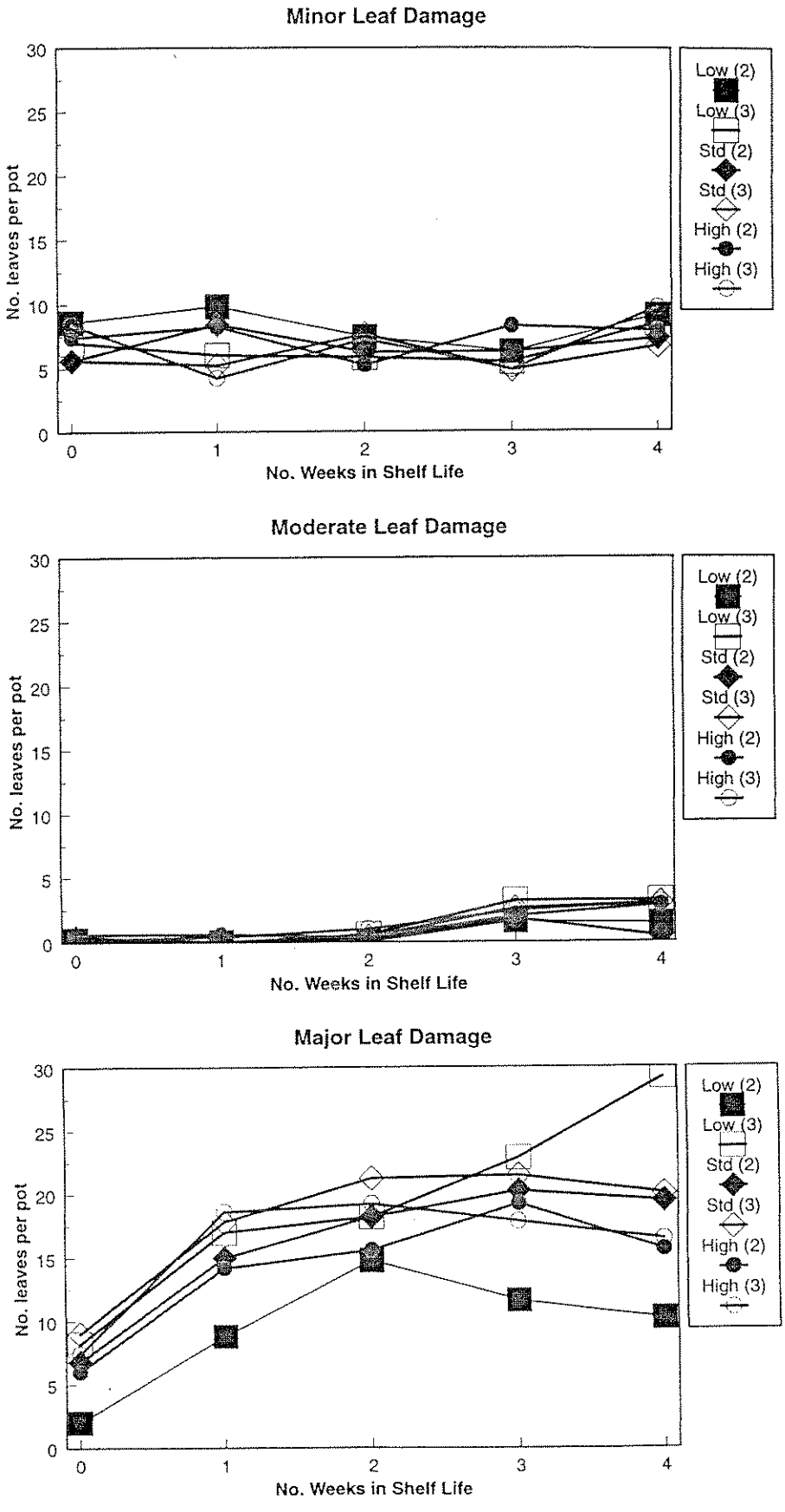


Figure 8

Leaf Quality in Shelf Life - Dark Yellow Boaldi - Stick Week 41
12 W/m^2(5000 lux) Supplementary Lighting

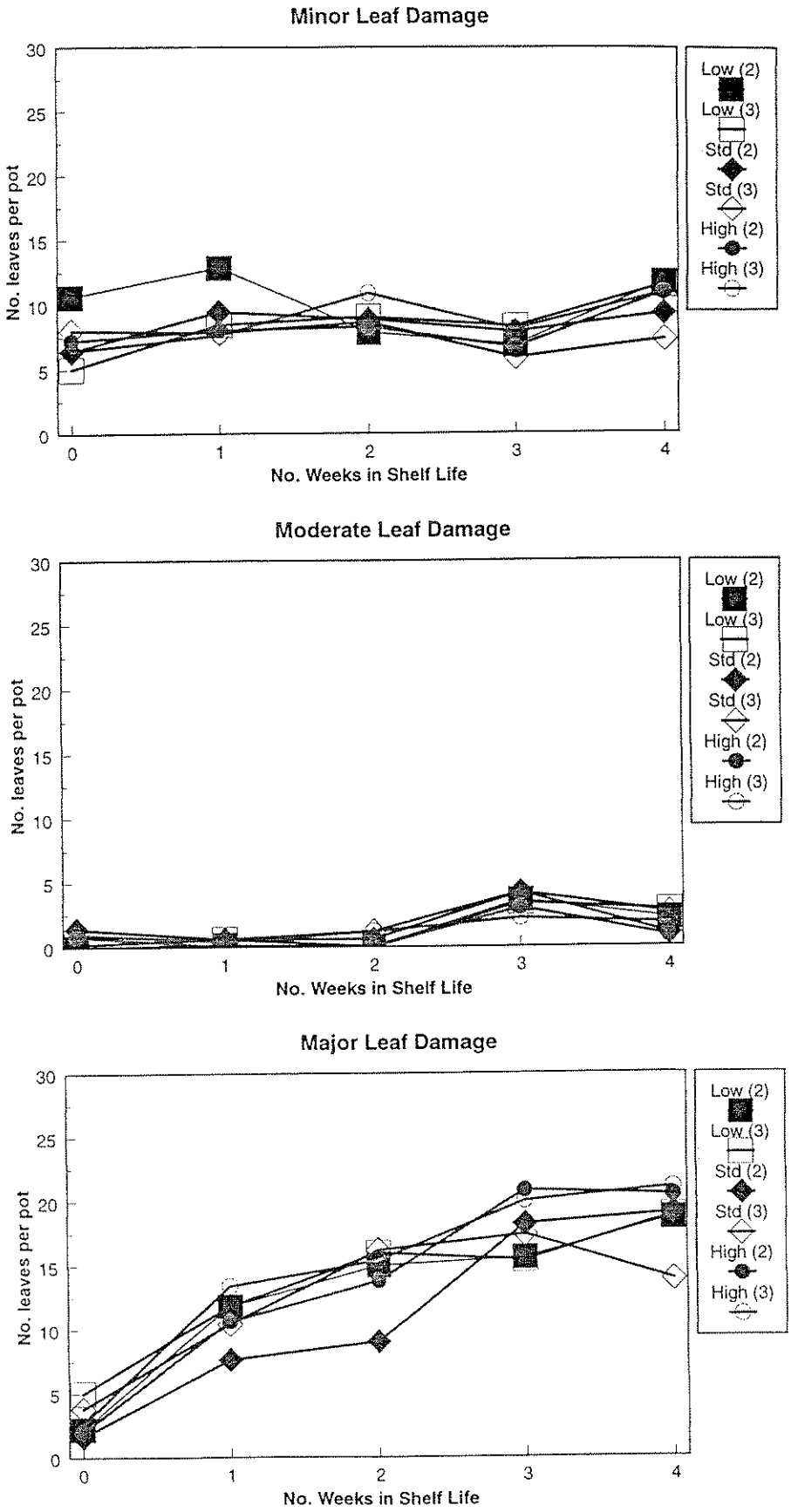


Figure 9

Leaf Quality in Shelf Life - Dark Yellow Boaldi - Stick Week 45
4.8 W/m^2(2000 lux) Supplementary Lighting

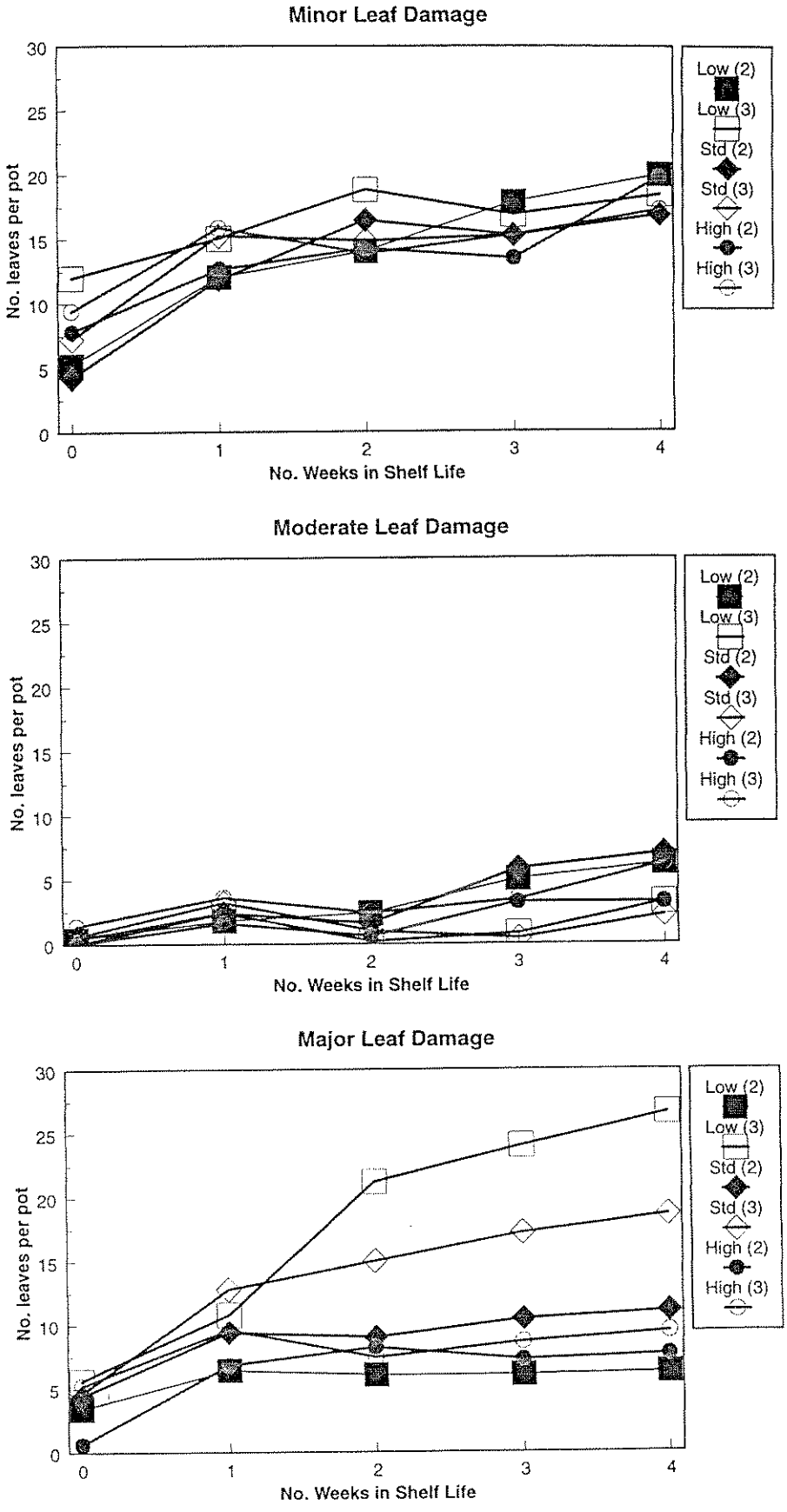


Figure 10

Leaf Quality in Shelf Life - Dark Yellow Boaldi - Stick Week 45
12 W/m^2(5000 lux) Supplementary Lighting

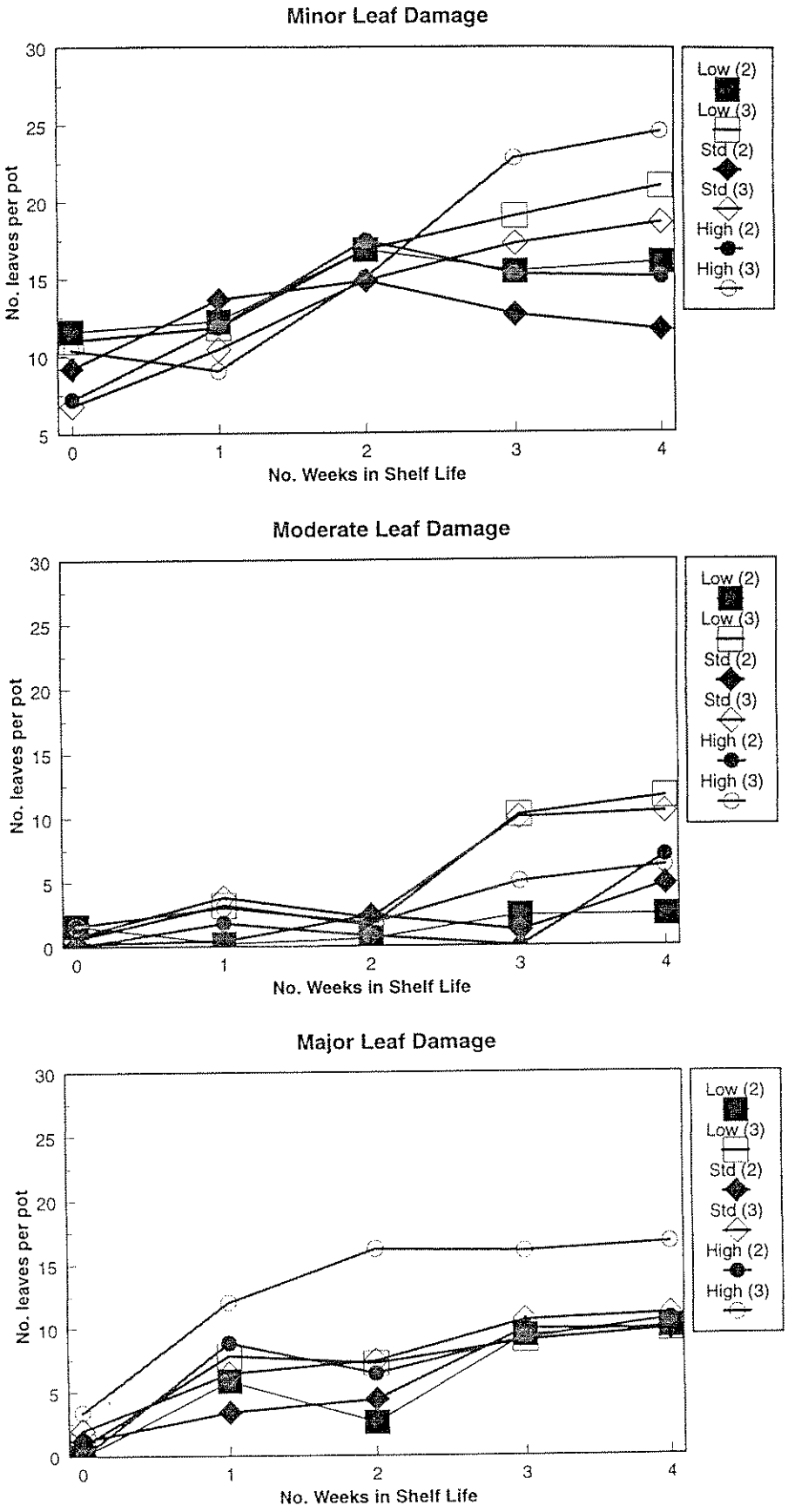


Figure 11

Leaf Quality in Shelf Life - Dark Yellow Boaldi - Stick Week 49
4.8 W/m^2(2000 lux) Supplementary Lighting

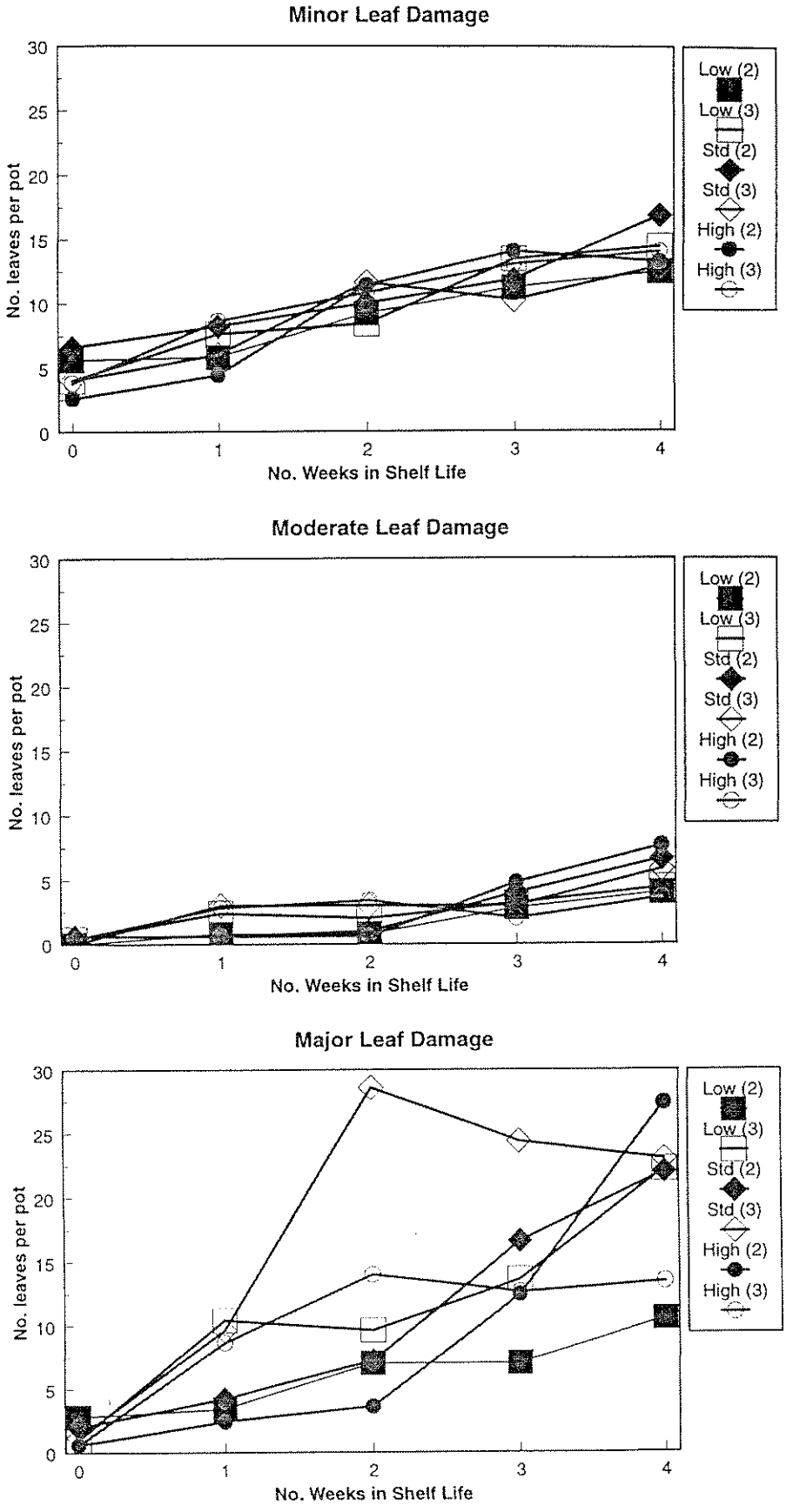


Figure 12

Leaf Quality in Shelf Life - Dark Yellow Boaldi - Stick Week 49
12 W/m^2(5000 lux) Supplementary Lighting

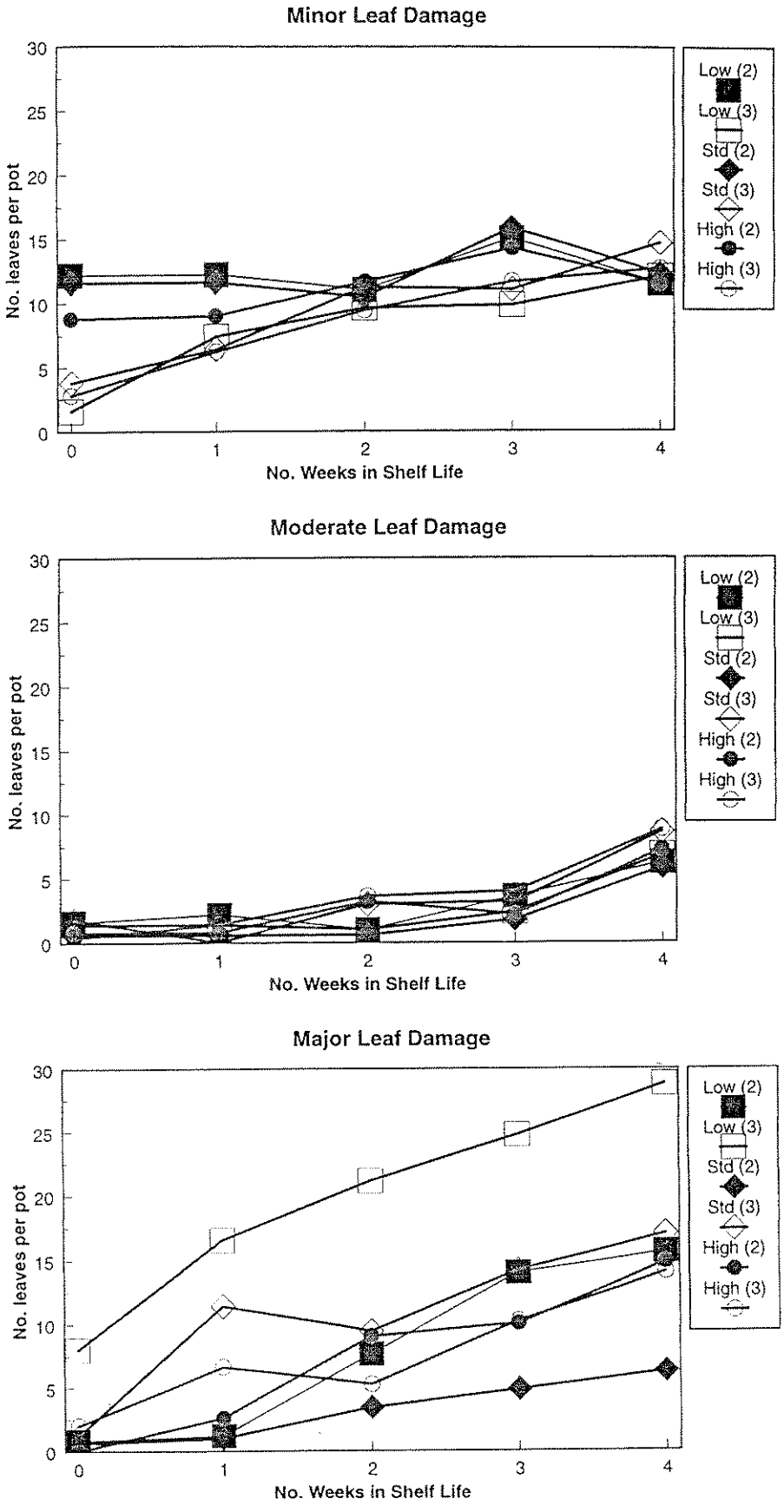


Figure 13

Flower Opening and Plant Deterioration in Shelf Life - Charm - Stick Week 41 4.8 W/m^2(2000 lux) Supplementary Lighting

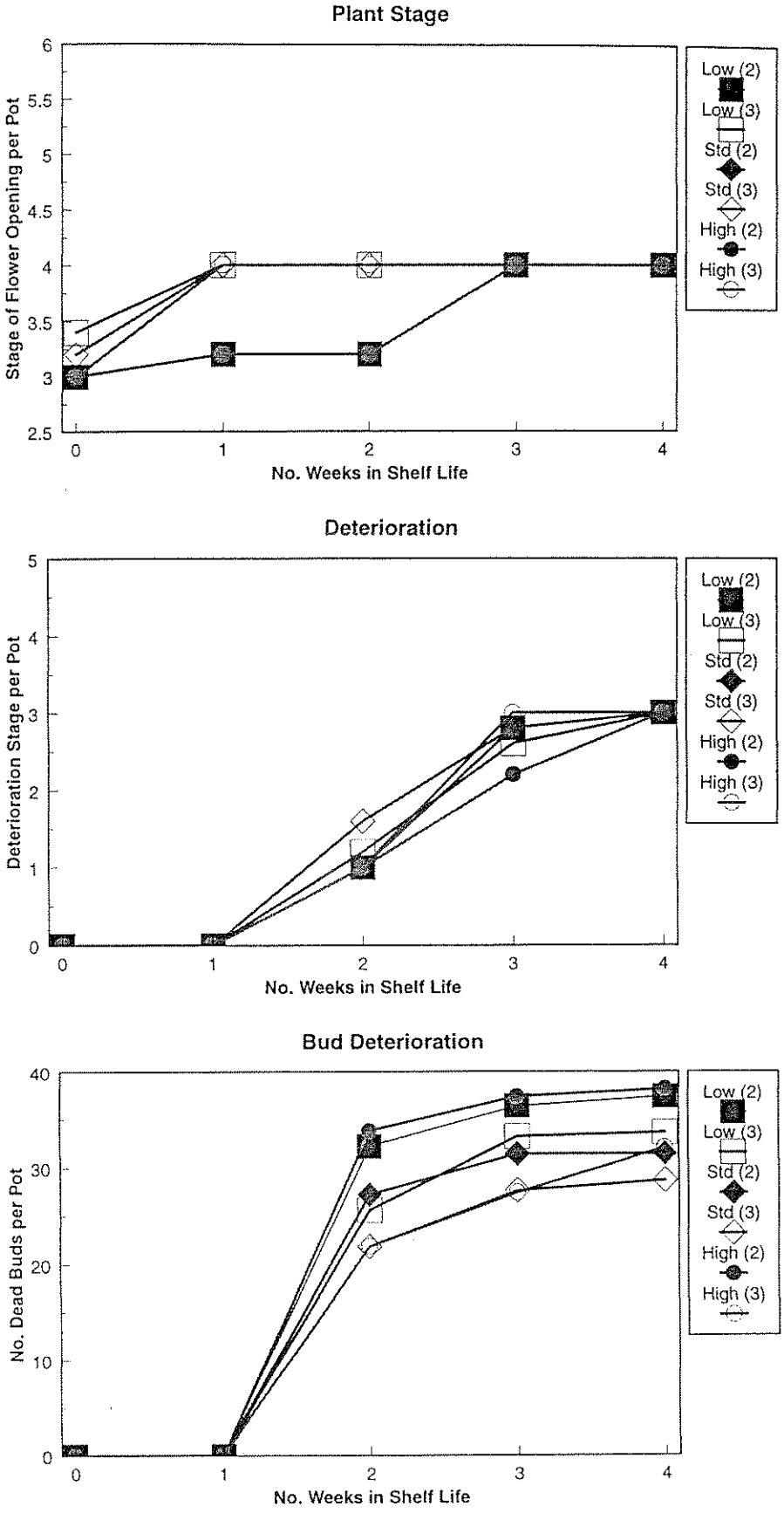


Figure 14

Flower Opening and Plant Deterioration in Shelf Life - Charm - Stick Week 41 12 W/m^2(5000 lux) Supplementary Lighting

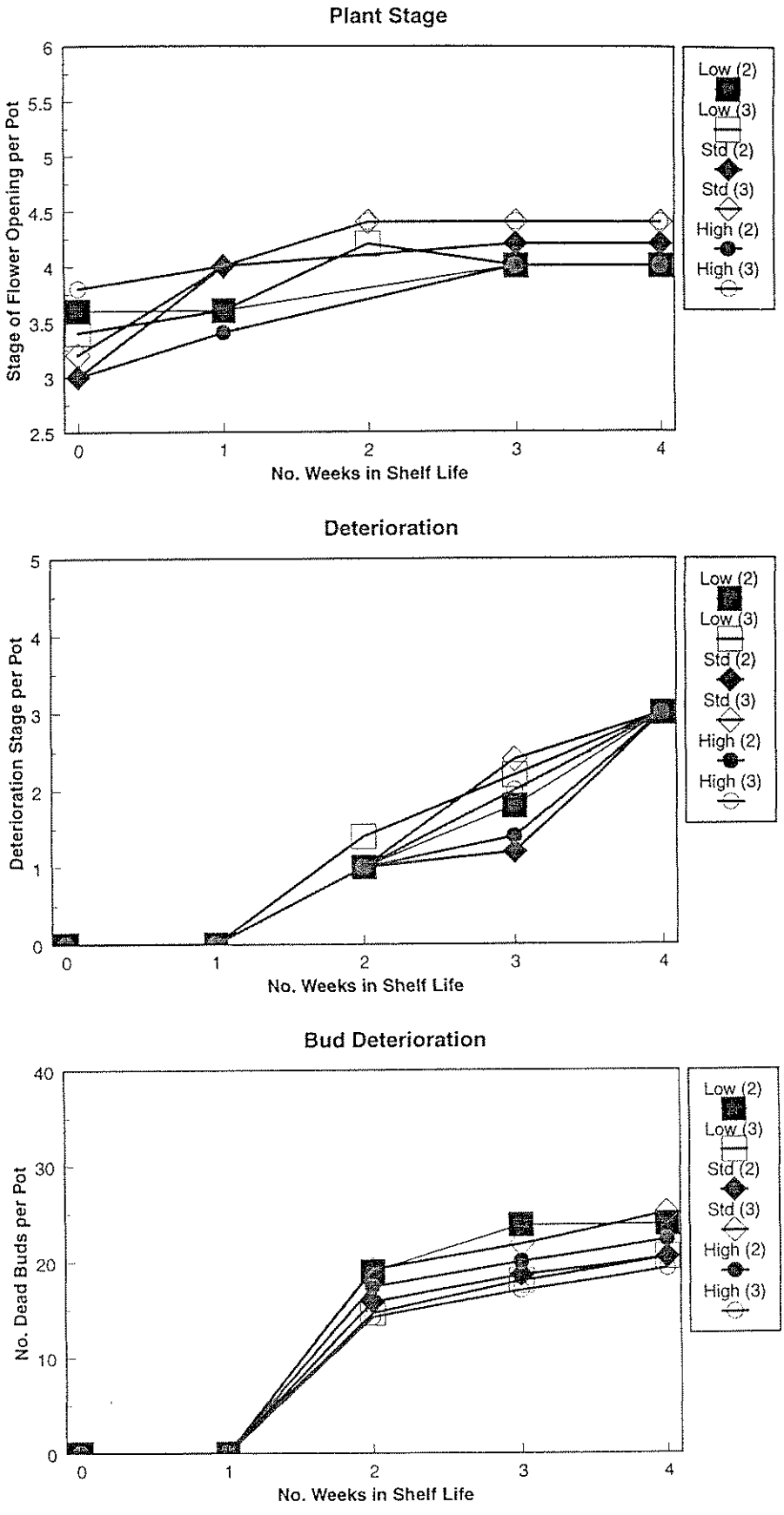


Figure 15

Flower Opening and Plant Deterioration in Shelf Life - Charm - Stick Week 45
4.8 W/m^2(2000 lux) Supplementary Lighting

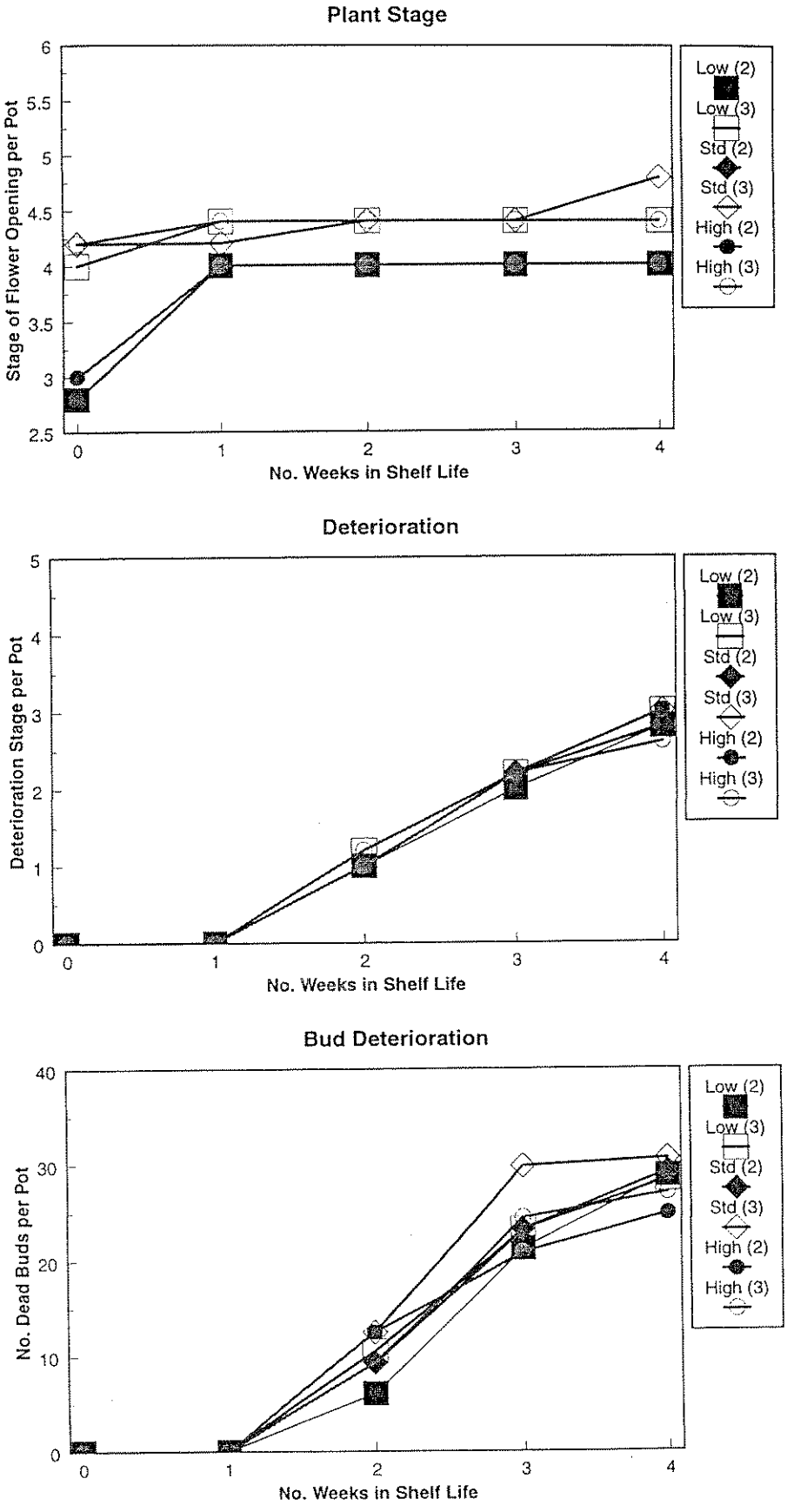


Figure 16

Flower Opening and Plant Deterioration in Shelf Life - Charm - Stick Week 45
12 W/m^2(5000 lux) Supplementary Lighting

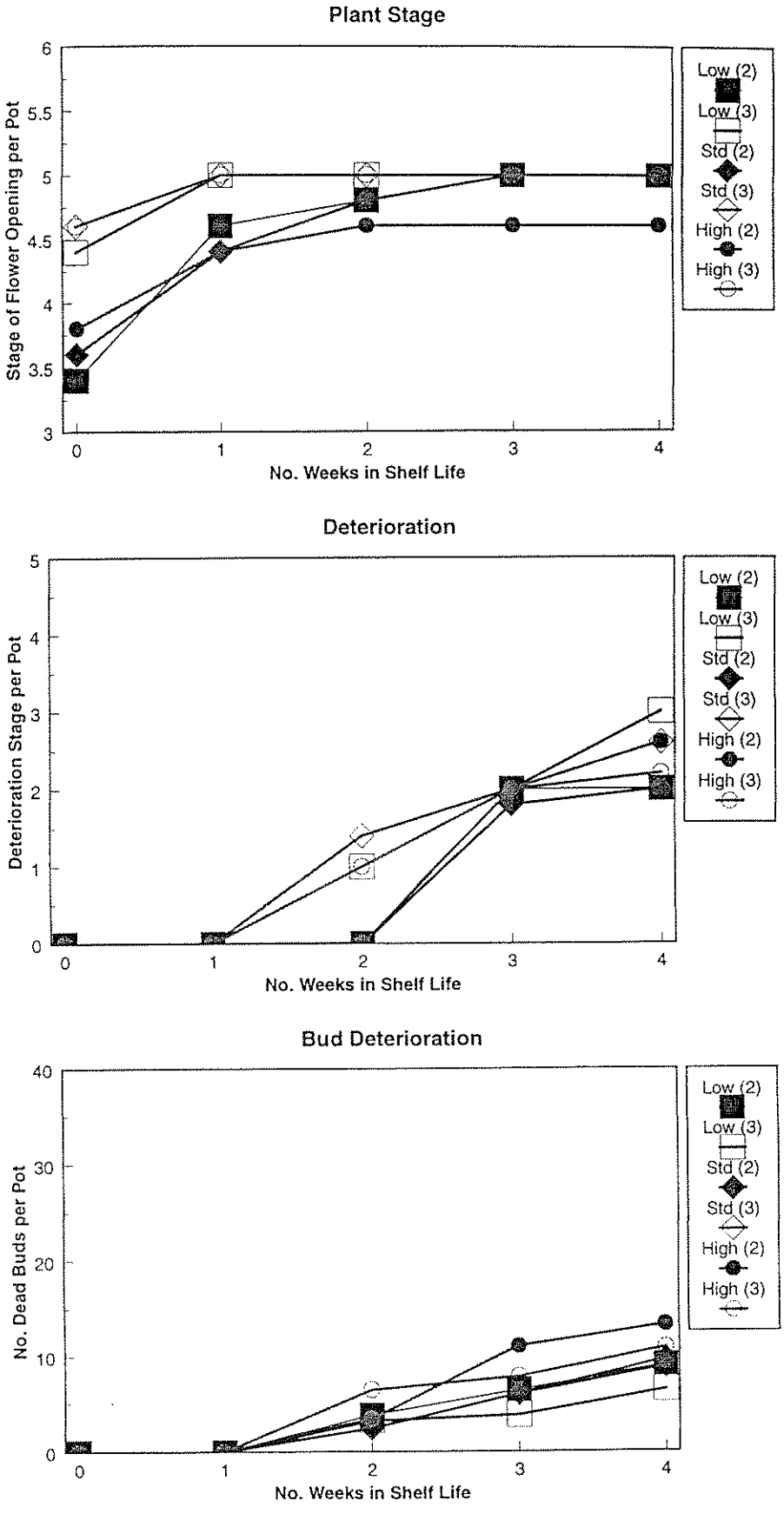


Figure 17

Flower Opening and Plant Deterioration in Shelf Life - Charm - Stick Week 49
4.8 W/m^2(2000 lux) Supplementary Lighting

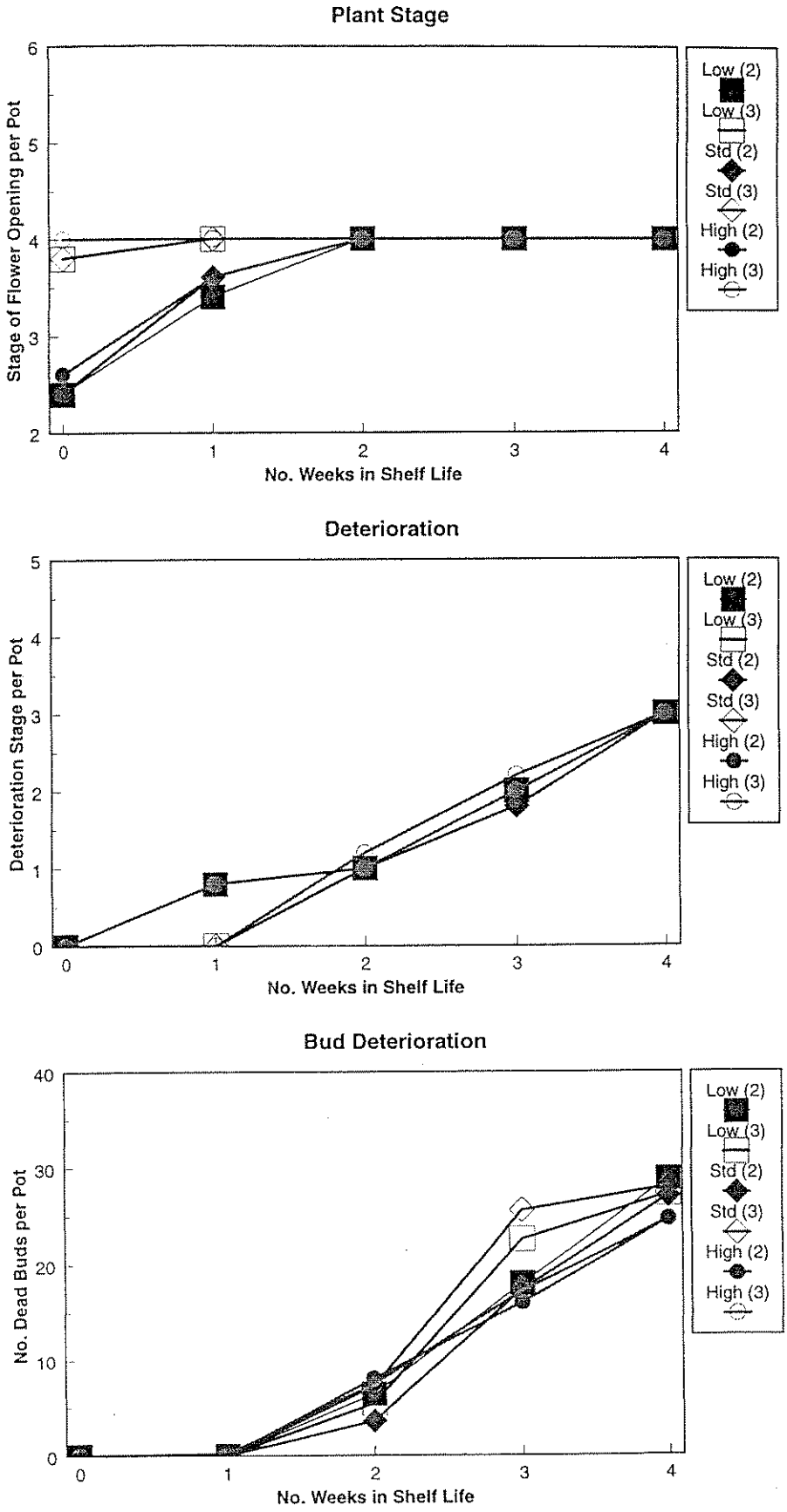
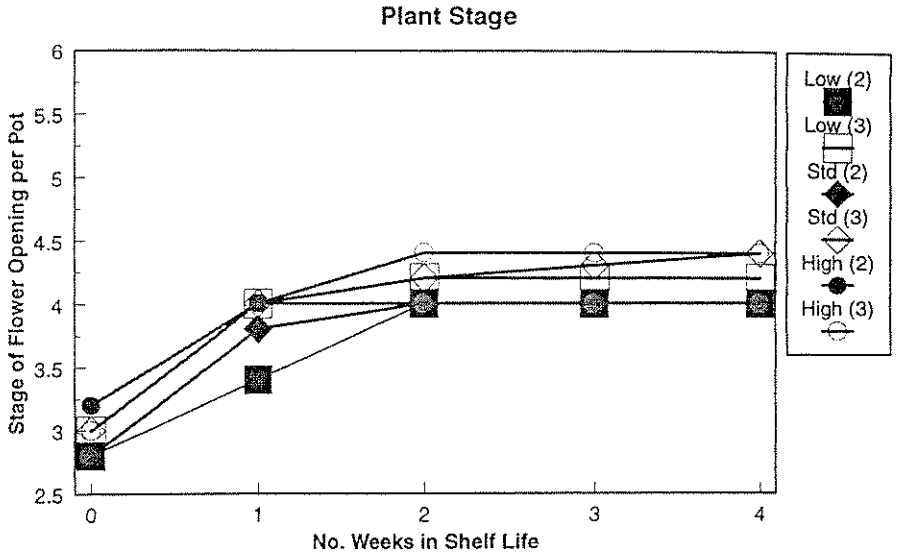
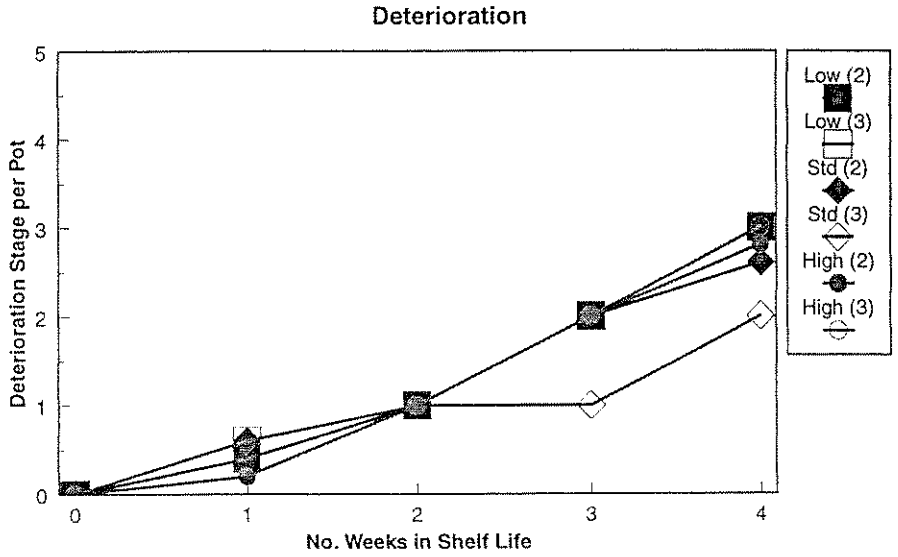


Figure 18

Flower Opening and Plant Deterioration in Shelf Life - Charm - Stick Week 49
12 W/m^2(5000 lux) Supplementary Lighting





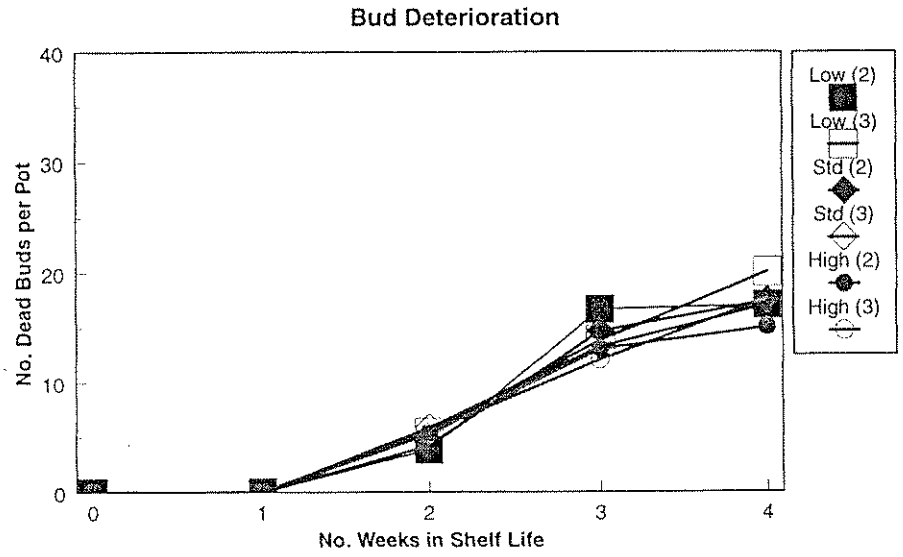


Figure 19

Flower Opening and Plant Deterioration in Shelf Life - Dark Yellow Boaldi - Stick Week 41
4.8 W/m^2(2000 lux) Supplementary Lighting

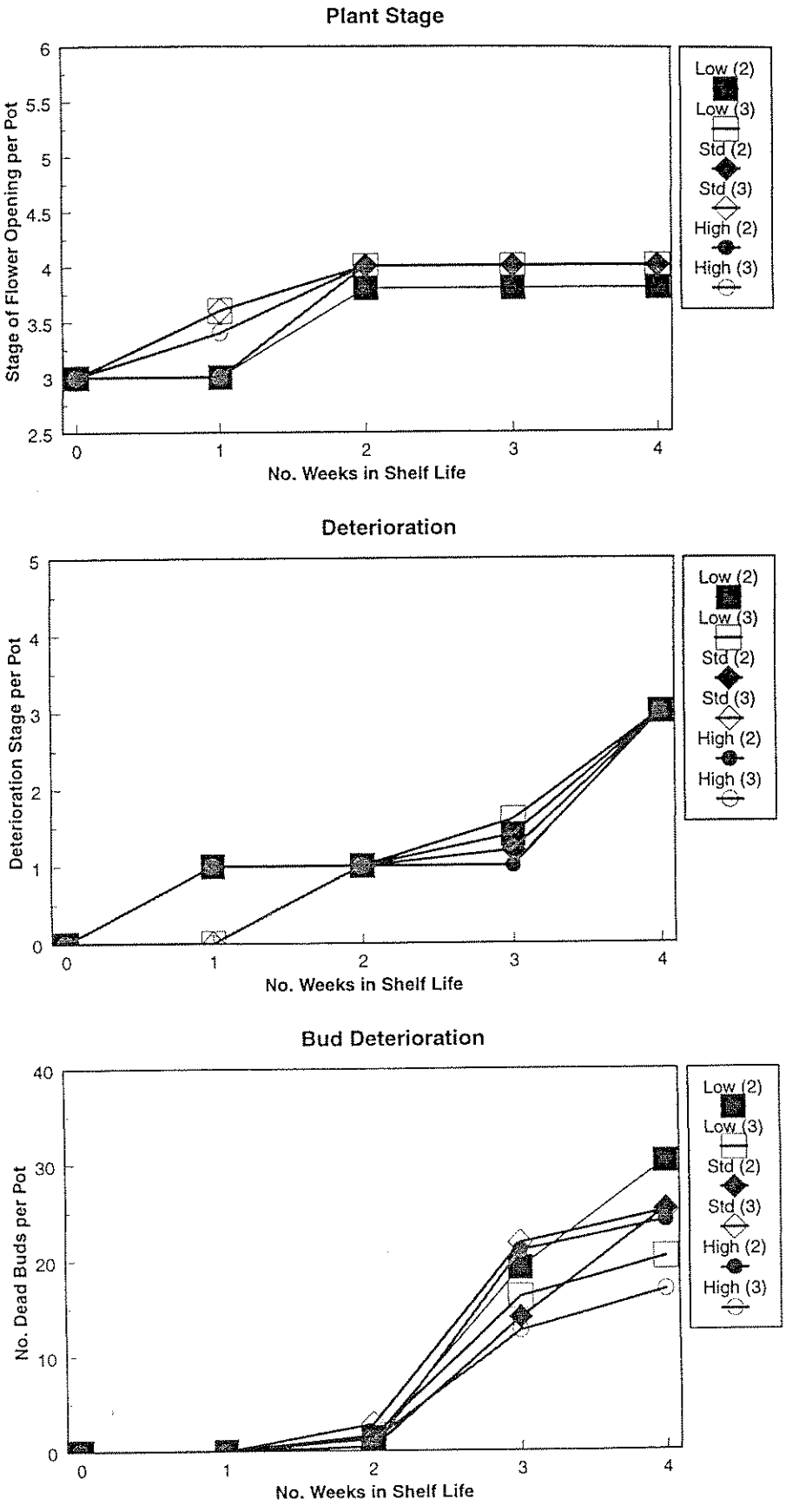


Figure 20

Flower Opening and Plant Deterioration in Shelf Life - Dark Yellow Boaldi - Stick Week 41
12 W/m^2(5000 lux) Supplementary Lighting

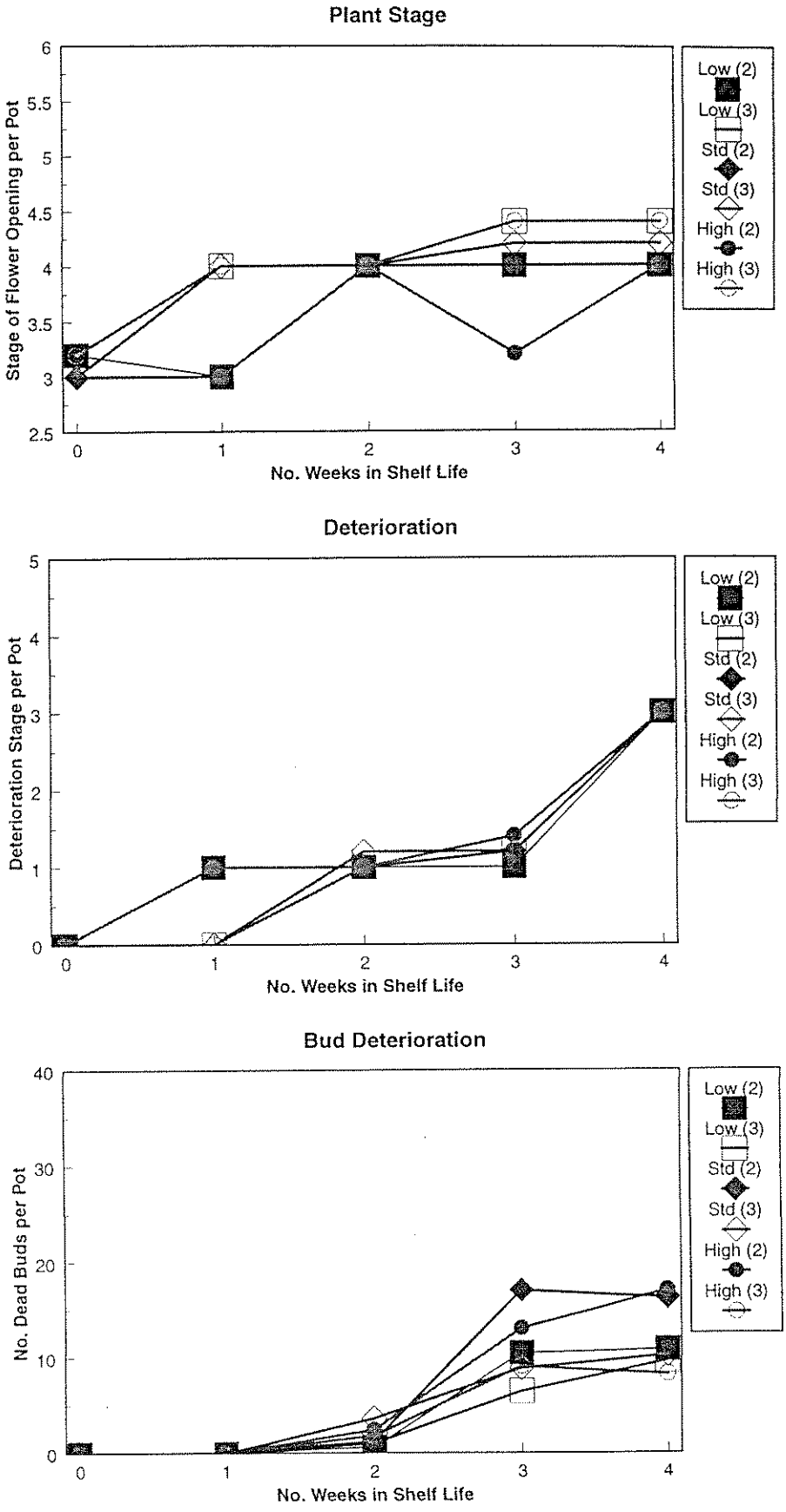


Figure 21

Flower Opening and Plant Deterioration in Shelf Life - Dark Yellow Boaldi - Stick Week 45
4.8 W/m^2(2000 lux) Supplementary Lighting

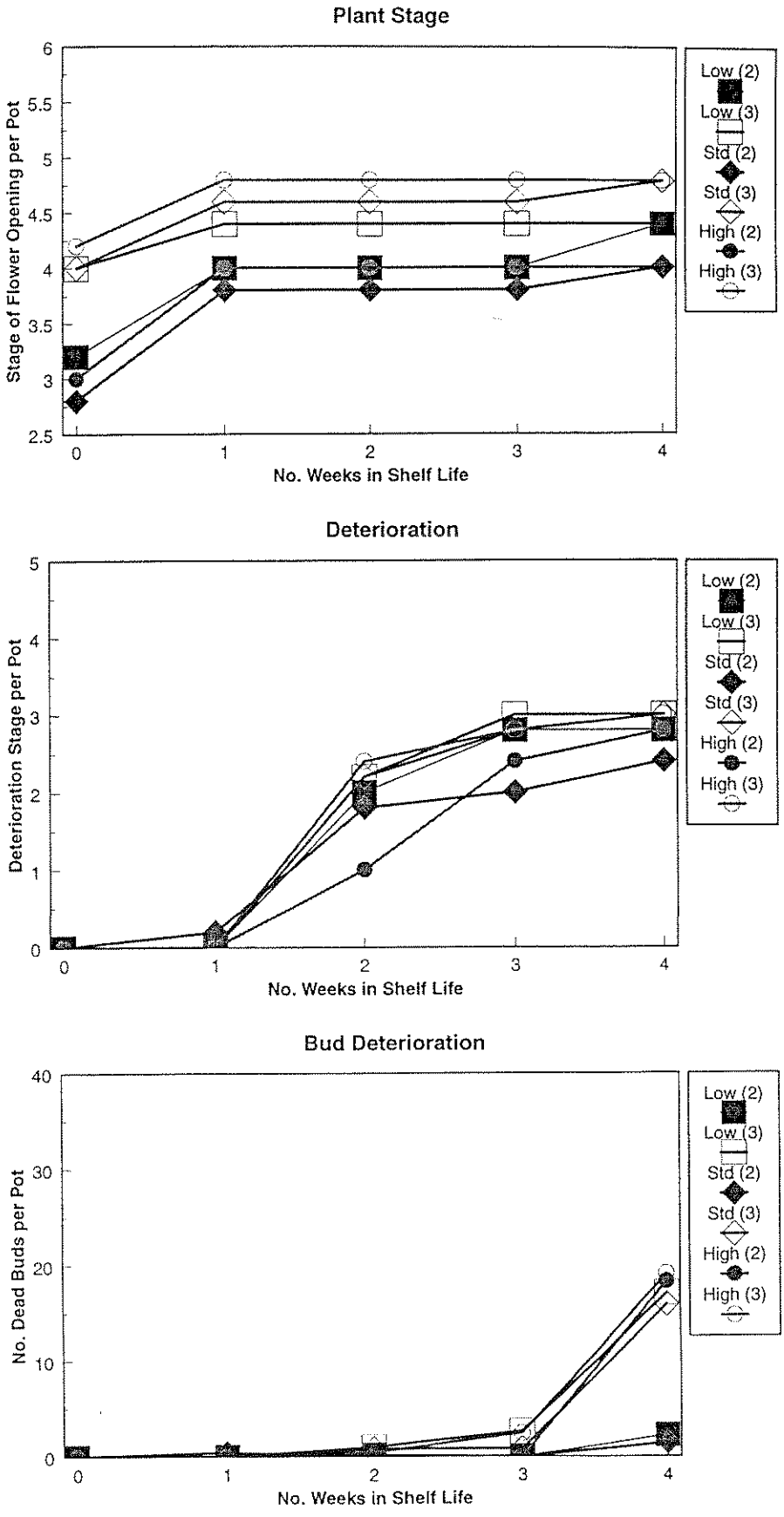
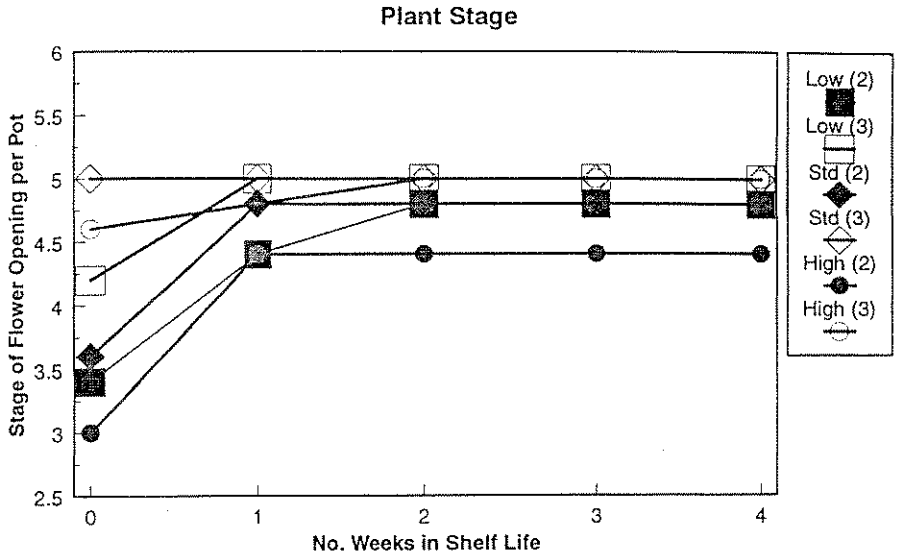
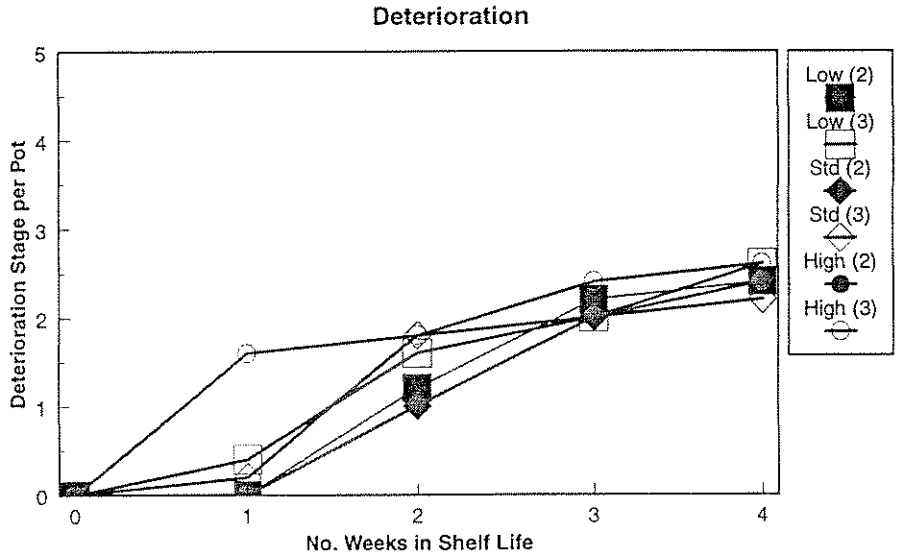


Figure 22

Flower Opening and Plant Deterioration in Shelf Life - Dark Yellow Boaldi - Stick Week 45
12 W/m^2(5000 lux) Supplementary Lighting





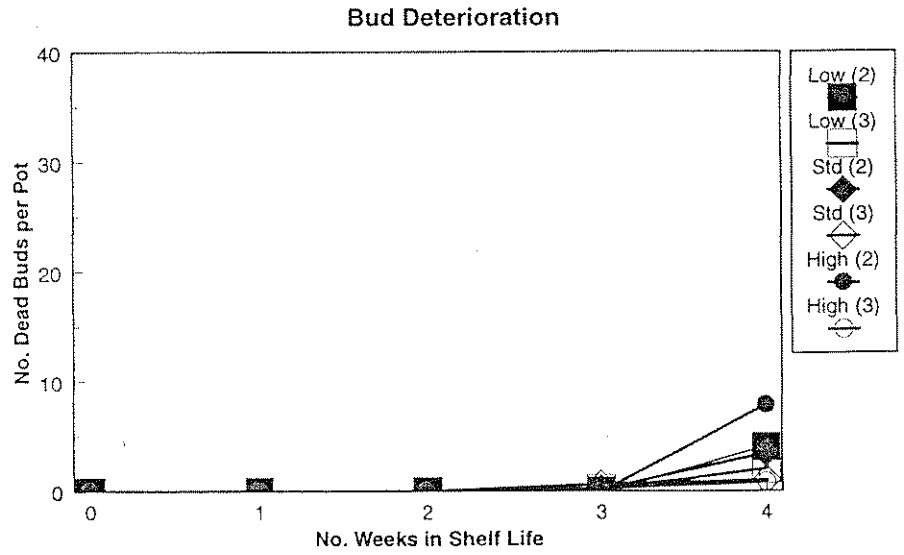
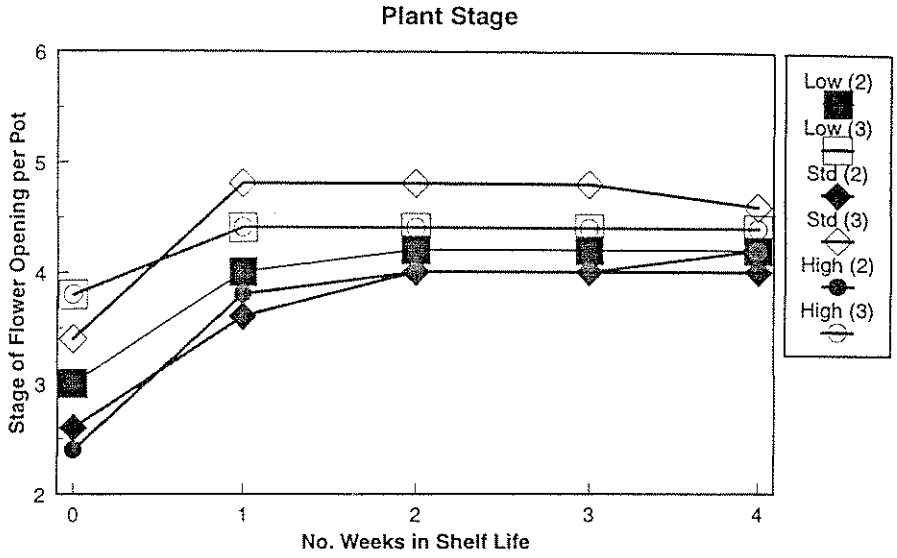
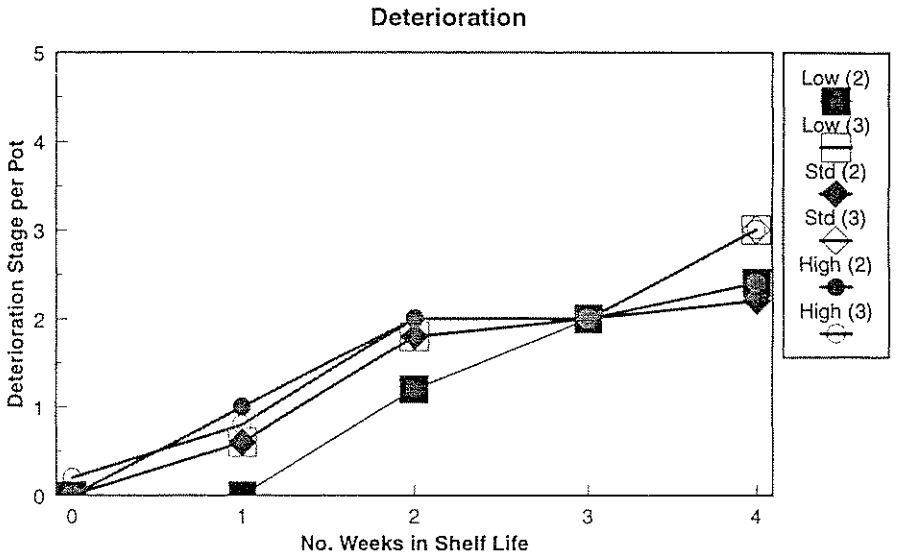


Figure 23

Flower Opening and Plant Deterioration in Shelf Life - Dark Yellow Boaldi - Stick Week 49 4.8 W/m^2(2000 lux) Supplementary Lighting





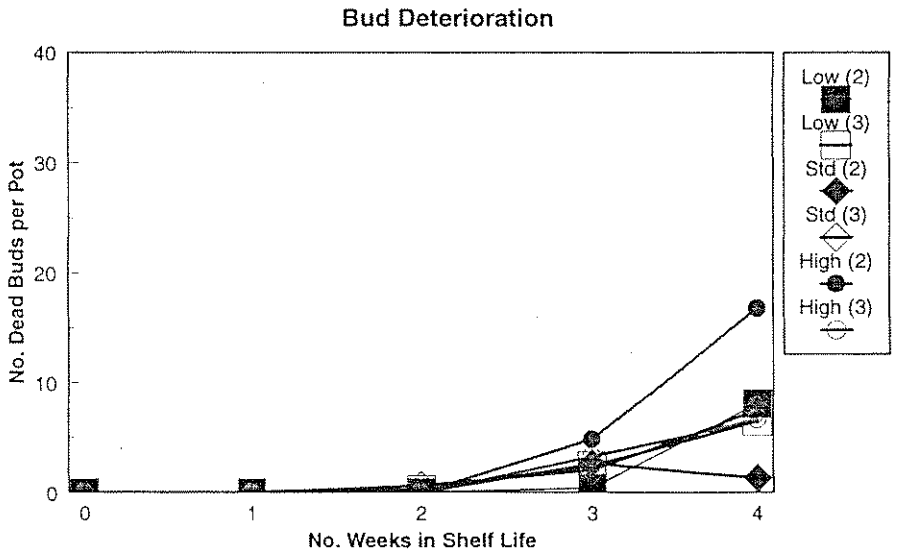
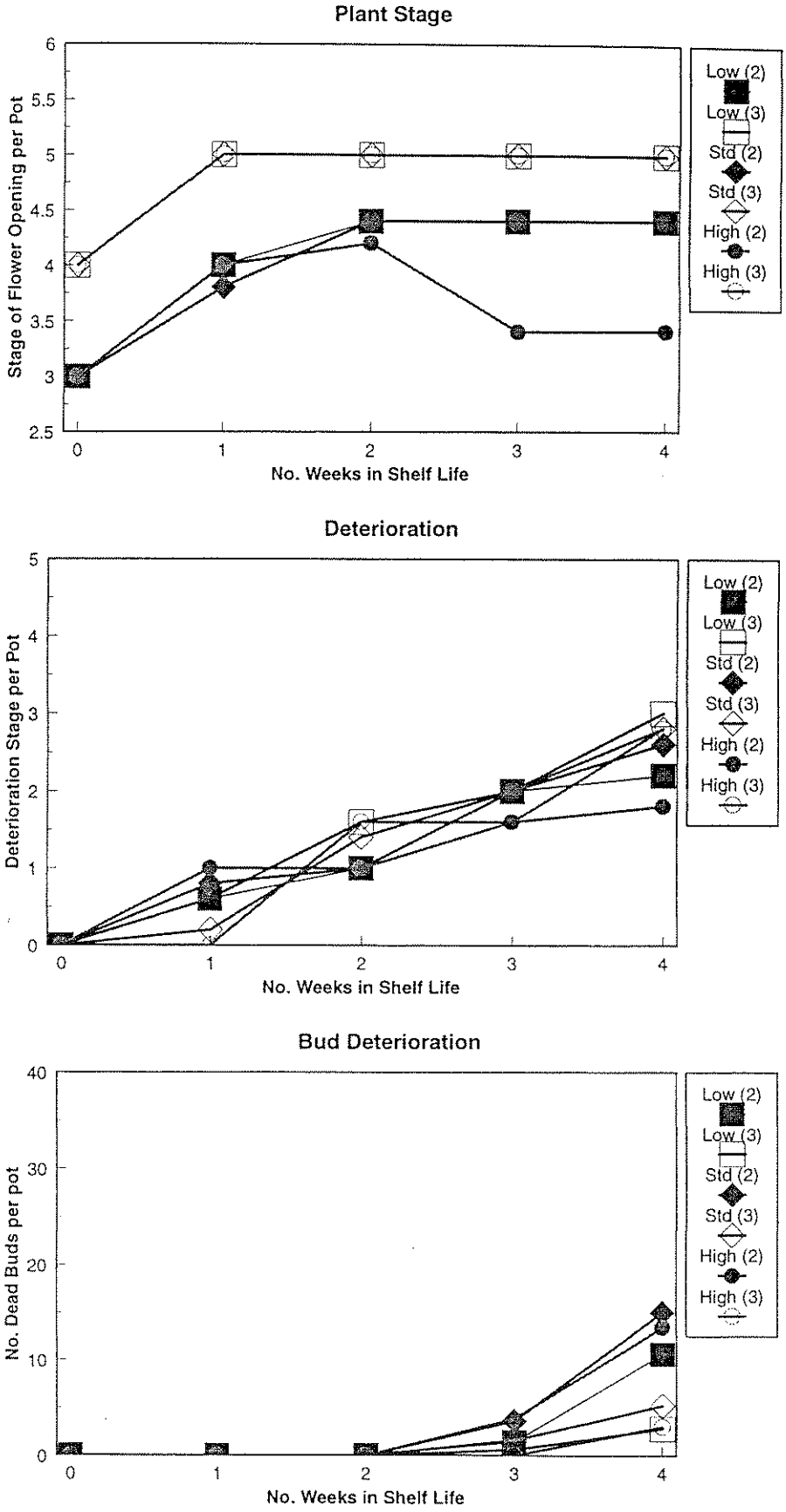


Figure 24

Flower Opening and Plant Deterioration in Shelf Life - Dark Yellow Boaldi - Stick Week 49 12 W/m^2(5000 lux) Supplementary Lighting



APPENDIX V

COMPOST ANALYSES

Table 1: **Main Trial - Compost Analyses**

Variety: **Charm** **Sample: 1 (week 4 of S.D.)**

Treatment	Sticking Date (week no)	pH	Ec µs/cm	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
A	41	5.6	540	286	8	47	133	180
A	45	6.8	267	111	4	36	58	85
A	49	5.7	291	103	0	42	37	114
B	41	5.5	412	196	5	37	75	131
B	45	6.3	135	32	2	23	14	39
B	49	5.5	458	145	0	75	54	203
C	41	5.7	392	166	3	32	34	138
C	45	5.9	344	148	11	38	100	101
C	49	5.6	262	71	0	39	35	104
D	41	5.7	302	116	2	32	36	98
D	45	5.8	274	121	5	32	88	76
D	49	5.6	384	96	0	64	26	174
E	41	5.8	311	80	6	25	24	107
E	45	6.0	201	55	3	28	23	69
E	49	6.0	263	6	0	34	5	100
F	41	5.8	288	79	2	25	22	98
F	45	5.8	262	76	3	37	25	91
F	49	6.3	159	23	0	31	12	47
G	41	5.6	331	95	2	35	23	116
G	45	5.9	243	72	3	35	22	86
G	49	5.8	271	47	0	42	18	99
H	41	5.8	202	42	3	20	17	59
H	45	5.8	306	108	3	42	42	109
H	49	5.7	349	78	0	47	17	140
J	41	5.5	352	123	2	33	36	122
J	45	6.0	164	42	2	27	18	51
J	49	6.1	160	4	0	21	7	48

Treatments

4.8 W/m² (2000 lux) throughout S.D.:

A Standard temperature regime (18/18°C)
B DROP weeks 1, 2 & 3 of S.D.
C DROP week 4 of S.D. to marketing
D DROP throughout S.D.

12 W/m² (5000 lux) weeks 1-3 S.D.:

E Standard temperature regime (18/18°C)
F DROP weeks 1, 2 & 3 of S.D.
GDROP week 4 of S.D. to marketing
H DROP throughout S.D.
J Standard temperature regime (18/18°C) + Daminozide

Table 2: **Main Trial - Compost Analyses**

Variety: **Charm** **Sample: 2 (week 8 of S.D.)**

Treatment	Sticking Date (week no)	pH	Ec µs/cm	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
A	41	5.1	473	265	4	29	136	141
A	45	5.7	229	111	2	22	24	82
A	49	5.8	197	81	1	19	22	68
B	41	4.7	649	354	4	33	169	198
B	45	5.9	173	85	2	12	14	61
B	49	5.8	182	84	6	31	46	48
C	41	5.2	340	159	3	28	64	111
C	45	6.0	98	24	2	11	7	30
C	49	6.2	164	62	3	14	36	41
D	41	6.1	251	118	3	21	56	74
D	45	6.1	96	18	2	12	5	30
D	49	6.2	121	23	3	15	16	37
E	41	5.4	361	167	3	26	66	121
E	45	6.0	131	39	3	9	20	40
E	49	6.1	221	76	3	24	23	78
F	41	5.7	299	134	2	25	50	99
F	45	6.1	139	38	3	15	18	43
F	49	5.9	157	90	2	17	34	45
G	41	5.6	292	117	3	29	24	111
G	45	6.2	100	8	2	12	6	31
G	49	5.9	229	95	2	25	40	84
H	41	5.9	192	48	2	16	22	61
H	45	6.2	73	6	2	11	9	19
H	49	6.0	219	68	3	20	20	77
J	41	5.6	282	133	3	22	69	84
J	45	5.6	290	87	2	18	37	107
J	49	6.2	154	48	1	18	25	49

Treatments

4.8 W/m² (2000 lux) throughout S.D.:

A Standard temperature regime (18/18°C)
B DROP weeks 1, 2 & 3 of S.D.
C DROP week 4 of S.D. to marketing
D DROP throughout S.D.

12 W/m² (5000 lux) weeks 1-3 S.D.:

E Standard temperature regime (18/18°C)
F DROP weeks 1, 2 & 3 of S.D.
G DROP week 4 of S.D. to marketing
H DROP throughout S.D.
J Standard temperature regime (18/18°C) + Daminozide

Table 3: **Main Trial - Compost Analyses**

Variety: **Dark Yellow Boaldi** **Sample: 1 (week 4 of S.D.)**

Treatment	Sticking Date (week no)	pH	Ec µs/cm	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
A	41	5.0	482	263	4	44	108	161
A	45	5.5	418	208	5	23	108	131
A	49	5.8	287	78	0	43	47	101
B	41	5.2	326	157	8	34	75	97
B	45	5.7	269	109	3	32	58	84
B	49	5.6	428	125	0	60	91	155
C	41	5.1	383	176	3	40	54	128
C	45	5.8	309	130	2	39	56	112
C	49	5.7	303	80	2	40	49	120
D	41	5.3	380	124	40	43	35	134
D	45	5.7	293	97	2	29	35	86
D	49	6.4	137	7	1	8	41	24
E	41	5.4	355	93	3	41	30	128
E	45	5.8	279	62	2	30	30	83
E	49	6.1	169	9	0	22	12	52
F	41	5.5	280	64	3	38	31	97
F	45	5.7	318	94	2	42	39	107
F	49	6.0	263	53	0	35	20	100
G	41	5.5	284	36	2	37	18	103
G	45	5.7	327	93	2	47	27	117
G	49	6.0	244	18	0	35	10	95
H	41	5.5	260	56	2	33	23	84
H	45	5.9	219	41	2	30	18	61
H	49	5.8	314	73	5	45	33	29
J	41	5.4	304	97	2	30	39	98
J	45	5.8	270	74	2	34	40	83
J	49	5.8	280	44	4	46	9	117

Treatments

4.8 W/m² (2000 lux) throughout S.D.:

A Standard temperature regime (18/18°C)
B DROP weeks 1, 2 & 3 of S.D.
C DROP week 4 of S.D. to marketing
D DROP throughout S.D.

12 W/m² (5000 lux) weeks 1-3 S.D.:

E Standard temperature regime (18/18°C)
F DROP weeks 1, 2 & 3 of S.D.
G DROP week 4 of S.D. to marketing
H DROP throughout S.D.
J Standard temperature regime (18/18°C) + Daminozide

Table 4: **Main Trial - Compost Analyses**

Variety: **Dark Yellow Boaldi** **Sample: 2 (week 8 of S.D.)**

Treatment	Sticking Date (week no)	pH	Ec µs/cm	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
A	41	4.8	643	387	4	39	215	208
A	45	5.5	337	149	5	17	32	121
A	49	5.8	271	137	1	21	36	98
B	41	4.6	687	392	3	36	179	224
B	45	5.6	295	121	4	21	27	106
B	49	6.0	213	76	1	14	23	74
C	41	5.1	396	203	3	23	49	140
C	45	5.6	222	84	4	15	35	70
C	49	5.9	306	110	1	10	21	112
D	41	5.2	452	208	4	29	52	162
D	45	5.9	220	53	2	7	15	61
D	49	6.0	333	99	3	15	34	117
E	41	5.4	379	177	1	19	64	124
E	45	5.9	342	63	3	9	27	68
E	49	6.0	304	116	2	28	36	111
F	41	5.4	297	131	2	22	41	102
F	45	5.6	298	101	3	24	25	101
F	49	5.9	322	118	3	20	36	118
G	41	5.6	279	90	2	20	22	94
G	45	5.8	247	68	2	15	27	75
G	49	6.0	243	53	3	18	15	93
H	41	5.7	236	81	1	16	24	75
H	45	6.1	159	19	2	12	10	44
H	49	5.9	327	115	3	12	26	118
J	41	5.3	354	167	1	21	80	111
J	45	5.8	197	58	1	12	19	56
J	49	5.9	263	99	2	24	40	88

Treatments

4.8 W/m² (2000 lux) throughout S.D.:

A Standard temperature regime (18/18°C)
B DROP weeks 1, 2 & 3 of S.D.
C DROP week 4 of S.D. to marketing
D DROP throughout S.D.

12 W/m² (5000 lux) weeks 1-3 S.D.:

E Standard temperature regime (18/18°C)
F DROP weeks 1, 2 & 3 of S.D.
G DROP week 4 of S.D. to marketing
H DROP throughout S.D.
J Standard temperature regime (18/18°C) + Daminozide

Table 5: Main Trial - Compost Analyses

Variety: Miramar Sample: 1 (week 4 of S.D.)

Treatment	Sticking Date (week no)	pH	Ec µs/cm	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
A	41	5.1	528	262	13	51	137	166
A	45	5.7	233	110	2	33	76	76
A	49	5.8	246	41	7	41	46	86
B	41	5.2	370	155	6	52	79	118
B	45	5.6	261	101	3	38	74	89
B	49	5.7	273	68	2	49	60	100
C	41	5.1	396	181	4	42	62	127
C	45	5.6	281	119	3	38	67	95
C	49	5.8	246	54	2	43	39	95
D	41	5.4	279	86	4	43	31	92
D	45	6.0	121	22	3	26	24	32
D	49	5.7	358	81	2	65	48	147
E	41	5.4	265	79	4	38	40	80
E	45	6.3	96	18	2	22	25	22
E	49	5.8	247	26	2	47	26	103
F	41	5.5	247	48	3	46	29	78
F	45	6.1	177	50	3	32	43	47
F	49	5.7	280	47	1	46	32	114
G	41	5.7	156	21	4	27	16	45
G	45	6.4	114	17	3	26	20	29
G	49	6.0	155	5	1	31	13	58
H	41	5.6	193	34	6	33	27	57
H	45	6.1	135	16	2	32	20	38
H	49	5.7	302	57	1	55	27	132
J	41	5.6	150	49	3	17	30	34
J	45	6.3	118	17	3	23	30	26
J	49	6.0	156	11	1	32	30	55

Treatments

4.8 W/m² (2000 lux) throughout S.D.:

A Standard temperature regime (18/18°C)
B DROP weeks 1, 2 & 3 of S.D.
C DROP week 4 of S.D. to marketing
D DROP throughout S.D.

12 W/m² (5000 lux) weeks 1-3 S.D.:

E Standard temperature regime (18/18°C)
F DROP weeks 1, 2 & 3 of S.D.
G DROP week 4 of S.D. to marketing
H DROP throughout S.D.
J Standard temperature regime (18/18°C) + Daminozide

Table 6: **Main Trial - Compost Analyses**

Variety: **Miramar** **Sample: 2 (week 8 of S.D.)**

Treatment	Sticking Date (week no)	pH	Ec µs/cm	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
A	41	4.7	493	295	2	23	211	131
A	45	5.8	220	94	1	17	40	67
A	49	6.1	171	27	2	19	25	52
B	41	4.9	513	294	2	27	133	162
B	45	5.9	185	77	1	14	31	60
B	49	5.8	163	61	2	24	46	44
C	41	5.0	347	169	2	24	61	112
C	45	5.9	148	34	1	7	15	38
C	49	6.3	124	21	2	14	34	28
D	41	5.3	280	123	0	27	56	82
D	45	6.1	180	37	1	6	18	50
D	49	6.1	236	69	2	26	28	78
E	41	5.3	355	151	2	36	59	120
E	45	6.2	130	25	1	12	16	33
E	49	6.1	160	42	2	25	22	54
F	41	5.6	218	67	2	27	26	67
F	45	6.1	182	49	2	23	19	45
F	49	6.0	172	72	2	23	57	44
G	41	5.5	262	62	1	33	22	92
G	45	6.3	118	8	2	9	8	20
G	49	6.2	157	14	2	19	27	48
H	41	5.7	202	42	1	28	23	63
H	45	6.0	188	11	2	18	8	47
H	49	5.9	199	56	2	24	42	66
J	41	5.3	379	155	1	45	62	127
J	45	6.1	153	24	2	13	19	30
J	49	5.9	199	74	3	30	37	62

Treatments

4.8 W/m² (2000 lux) throughout S.D.:

A Standard temperature regime (18/18°C)
B DROP weeks 1, 2 & 3 of S.D.
C DROP week 4 of S.D. to marketing
D DROP throughout S.D.

12 W/m² (5000 lux) weeks 1-3 S.D.:

E Standard temperature regime (18/18°C)
F DROP weeks 1, 2 & 3 of S.D.
G DROP week 4 of S.D. to marketing
H DROP throughout S.D.
J Standard temperature regime (18/18°C) + Daminozide

Table 7: Spacing Observation Trial - Compost Analyses

Variety: Charm Sample: 1 (week 4 of S.D.)

Treatment	Sticking Date (week no)	pH	Ec µs/cm	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
M	41	5.2	492	243	5	46	105	172
M	45	5.6	284	116	2	39	79	89
M	49	5.7	275	92	5	47	71	104
N	41	5.5	309	112	4	31	41	101
N	45	6.0	136	32	2	28	26	39
N	49	5.6	351	98	1	54	41	152
O	41	5.6	235	63	2	26	25	81
O	45	5.9	276	86	2	45	45	97
O	49	5.7	274	43	1	50	9	127
P	41	5.6	215	45	3	28	20	71
P	45	6.0	194	54	1	38	32	65
P	49	5.7	298	63	1	41	26	117

Treatments

4.8 W/m² (2000 lux) throughout S.D.:

M Standard temperature regime (18/18°C) + close spacing

N DROP throughout S.D. + close spacing

12 W/m² (5000 lux) weeks 1-3 S.D.:

O Standard temperature regime (18/18°C) + close spacing

P DROP throughout S.D. + close spacing

Table 8: Spacing Observation Trial - Compost Analyses

Variety: Charm Sample: 2 (week 8 of S.D.)

Treatment	Sticking Date (week no)	pH	Ec µs/cm	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
M	41	5.3	481	266	2	29	169	132
M	45	5.7	189	72	2	20	39	42
M	49	5.6	260	130	2	34	62	93
N	41	5.6	294	115	1	22	50	90
N	45	6.0	177	33	2	12	21	37
N	49	6.1	138	19	2	25	29	42
O	41	5.7	355	113	1	31	55	120
O	45	6.1	117	37	2	13	25	33
O	49	6.1	164	73	2	22	40	47
P	41	5.9	259	73	1	25	23	89
P	45	6.2	192	14	2	14	74	32
P	49	5.8	228	107	2	20	38	68

Treatments

4.8 W/m² (2000 lux) throughout S.D.:

M Standard temperature regime (18/18°C) + close spacing

N DROP throughout S.D. + close spacing

12 W/m² (5000 lux) weeks 1-3 S.D.:

O Standard temperature regime (18/18°C) + close spacing

P DROP throughout S.D. + close spacing

Table 9: Spacing Observation Trial - Compost Analyses

Variety: Dark Yellow Boaldi Sample: 1 (week 4 of S.D.)

Treatment	Sticking Date (week no)	pH	Ec µs/cm	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
M	41	4.9	542	297	30	47	151	154
M	45	5.5	360	169	1	43	81	124
M	49	6.0	347	107	3	53	58	141
N	41	5.4	252	90	3	28	34	77
N	45	5.7	280	122	2	29	69	89
N	49	5.8	289	92	2	48	69	104
O	41	5.3	284	106	4	26	41	88
O	45	5.7	313	109	1	38	47	114
O	49	5.9	201	18	2	32	15	80
P	41	5.4	270	74	3	37	30	92
P	45	5.8	273	104	1	38	44	96
P	49	5.7	293	77	2	45	38	121

Treatments

4.8 W/m² (2000 lux) throughout S.D.:

M Standard temperature regime (18/18°C) + close spacing

N DROP throughout S.D. + close spacing

12 W/m² (5000 lux) weeks 1-3 S.D.:

O Standard temperature regime (18/18°C) + close spacing

P DROP throughout S.D. + close spacing

Table 10: Spacing Observation Trial - Compost Analyses

Variety: Dark Yellow Boaldi Sample: 2 (week 8 of S.D.)

Treatment	Sticking Date (week no)	pH	Ec μs/cm	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
M	41	4.7	674	357	3	36	212	198
M	45	5.5	548	162	3	17	311	105
M	49	5.7	314	138	3	22	23	114
N	41	5.3	376	159	2	14	49	108
N	45	5.8	168	52	2	9	31	37
N	49	5.9	396	122	3	27	32	154
O	41	5.4	401	189	1	13	60	120
O	45	5.9	193	58	2	10	41	39
O	49	6.1	273	81	1	31	36	97
P	41	5.7	248	72	1	18	19	77
P	45	6.2	127	17	1	15	13	24
P	49	5.8	309	113	1	28	25	119

Treatments

4.8 W/m² (2000 lux) throughout S.D.:

M Standard temperature regime (18/18°C) + close spacing

N DROP throughout S.D. + close spacing

12 W/m² (5000 lux) weeks 1-3 S.D.:

O Standard temperature regime (18/18°C) + close spacing

P DROP throughout S.D. + close spacing

Table 11: Spacing Observation Trial - Compost Analyses

Variety: Miramar Sample: 1 (week 4 of S.D.)

Treatment	Sticking Date (week no)	pH	Ec µs/cm	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
M	41	4.9	498	288	5	55	137	153
M	45	5.7	299	150	1	36	78	101
M	49	5.7	326	91	2	62	42	143
N	41	5.3	263	112	3	31	48	79
N	45	5.7	293	116	1	40	55	101
N	49	5.6	371	107	2	66	76	150
O	41	5.3	283	97	3	45	56	90
O	45	6.1	130	34	3	27	31	37
O	49	5.9	227	29	2	47	15	96
P	41	5.4	286	88	5	48	50	92
P	45	6.3	115	19	1	28	18	34
P	49	6.0	191	21	1	41	23	68

Treatments

4.8 W/m² (2000 lux) throughout S.D.:

M Standard temperature regime (18/18°C) + close spacing

N DROP throughout S.D. + close spacing

12 W/m² (5000 lux) weeks 1-3 S.D.:

O Standard temperature regime (18/18°C) + close spacing

P DROP throughout S.D. + close spacing

Table 12: Spacing Observation Trial - Compost Analyses

Variety: Miramar Sample: 2 (week 8 of S.D.)

Treatment	Sticking Date (week no)	pH	Ec µs/cm	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
M	41	4.9	594	325	2	40	175	177
M	45	5.9	192	84	1	17	41	64
M	49	5.7	222	102	1	22	36	80
N	41	5.2	433	207	1	26	84	128
N	45	6.0	130	25	1	10	14	38
N	49	6.2	134	24	2	23	28	34
O	41	5.4	312	119	1	31	32	98
O	45	6.3	100	18	1	7	15	26
O	49	6.1	173	74	1	23	39	51
P	41	5.7	310	89	1	30	49	77
P	45	6.5	73	5	0	9	7	17
P	49	5.9	233	69	1	30	38	79

Treatments

4.8 W/m² (2000 lux) throughout S.D.:

M Standard temperature regime (18/18°C) + close spacing

N DROP throughout S.D. + close spacing

12 W/m² (5000 lux) weeks 1-3 S.D.:

O Standard temperature regime (18/18°C) + close spacing

P DROP throughout S.D. + close spacing

Table 13: Nutrition Observation Trial - Compost Analyses

Variety: Charm Sample: 1 (week 4 of S.D.)

Treatment	Sticking Date (week no)	pH	Ec µs/cm	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
T	41	5.2	468	215	3	48	86	165
T	45	6.0	147	36	3	30	32	42
T	49	5.8	324	95	2	63	68	131
V	41	5.2	554	289	32	46	168	160
V	45	5.8	329	142	2	43	69	111
V	49	5.8	274	73	2	40	29	106
W	41	5.2	512	264	11	40	152	140
W	45	5.6	221	99	1	27	66	65
W	49	5.8	294	88	2	54	49	118
X	41	5.6	253	91	3	20	43	73
X	45	6.2	240	62	2	37	34	90
X	49	5.8	323	67	1	47	31	138
Y	41	5.5	322	89	5	28	1500	103
Y	45	5.9	252	83	2	35	45	80
Y	49	5.9	276	21	3	45	22	103
Z	41	5.5	353	105	2	28	1190	110
Z	45	5.8	254	82	6	36	33	90
Z	49	5.7	323	92	3	46	39	122

Treatments

Standard temperature regime:

4.8 W/m² (2000 lux) throughout S.D.

T Low feed
V Standard feed
W High feed

12 W/m² (5000 lux) weeks 1-3 of S.D.

X Low feed
Y Standard feed
Z High feed

Table 14: Nutrition Observation Trial - Compost Analyses

Variety: Charm Sample: 2 (week 8 of S.D.)

Treatment	Sticking Date (week no)	pH	Ec µs/cm	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
T	41	5.4	447	225	1	27	131	139
T	45	6.2	154	49	4	17	35	53
T	49	6.0	141	58	1	24	51	33
V	41	5.0	519	281	2	30	149	157
V	45	5.8	191	69	1	15	46	56
V	49	6.0	146	55	2	24	37	38
W	41	4.8	524	278	2	24	178	141
W	45	5.7	244	115	0	16	36	83
W	49	5.7	193	104	0	23	61	53
X	41	5.6	301	120	1	23	88	78
X	45	5.6	201	96	0	20	47	67
X	49	5.8	204	109	0	28	87	49
Y	41	5.7	304	131	0	19	80	83
Y	45	5.7	300	59	10	13	18	70
Y	49	6.0	266	60	1	29	31	101
Z	41	5.7	342	141	1	26	64	107
Z	45	5.4	369	163	0	19	21	146
Z	49	5.6	415	223	0	27	80	140

Treatments

Standard temperature regime:

4.8 W/m² (2000 lux) throughout S.D.

T Low feed
V Standard feed
W High feed

12 W/m² (5000 lux) weeks 1-3 of S.D.

X Low feed
Y Standard feed
Z High feed

Table 15: Nutrition Observation Trial - Compost Analyses

Variety: Charm **Sample: End of shelf life**
Marketing stage: 2

Treatment	Sticking Date (week no)	pH	Ec µs/cm	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
T	41	5.7	252	118	3	13	71	66
T	45	6.4	161	51	4	11	36	39
T	49	6.3	128	40	3	11	32	28
V	41	5.2	349	177	2	17	114	89
V	45	6.2	175	59	3	8	27	43
V	49	5.8	229	107	2	17	35	78
W	41	4.9	592	315	4	20	208	158
W	45	6.4	156	58	2	9	29	36
W	49	6.0	142	61	2	11	27	39
X	41	5.6	270	99	2	18	54	76
X	45	6.2	184	85	2	13	56	39
X	49	6.0	173	89	2	14	52	47
Y	41	5.9	182	60	2	13	53	43
Y	45	6.3	141	36	2	11	29	31
Y	49	6.2	166	80	2	12	48	41
Z	41	5.7	199	81	2	11	56	49
Z	45	6.2	177	61	2	12	31	44
Z	49	5.7	352	181	1	23	79	111

Treatments

Standard temperature regime:

4.8 W/m² (2000 lux) throughout S.D.

T Low feed
V Standard feed
W High feed

12 W/m² (5000 lux) weeks 1-3 of S.D.

X Low feed
Y Standard feed
Z High feed

Table 16: Nutrition Observation Trial - Compost Analyses

Variety: Charm **Sample: End of shelf life**
Marketing stage: 3

Treatment	Sticking Date (week no)	pH	Ec µs/cm	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
T	41	5.3	288	139	2	12	63	79
T	45	6.6	101	14	3	7	17	16
T	49	6.5	86	19	2	8	16	18
V	41	4.8	410	218	3	20	116	111
V	45	6.3	202	60	4	9	17	46
V	49	6.0	170	66	2	17	38	47
W	41	5.2	250	126	2	13	110	55
W	45	6.4	113	25	3	7	20	20
W	49	6.2	139	43	2	10	26	36
X	41	6.0	140	34	3	13	63	28
X	45	6.1	169	53	3	13	31	40
X	49	6.1	145	61	1	20	66	29
Y	41	5.7	181	85	3	15	44	44
Y	45	6.4	116	22	3	10	29	21
Y	49	6.3	142	56	2	14	34	33
Z	41	5.9	108	36	2	15	31	25
Z	45	6.2	143	42	3	13	35	29
Z	49	5.9	192	105	1	18	60	66

Treatments

Standard temperature regime:

4.8 W/m² (2000 lux) throughout S.D.

T Low feed
V Standard feed
W High feed

12 W/m² (5000 lux) weeks 1-3 of S.D.

X Low feed
Y Standard feed
Z High feed

Table 17: Nutrition Observation Trial - Compost Analyses

Variety: Dark Yellow Boaldi Sample: 1 (week 4 of S.D.)

Treatment	Sticking Date (week no)	pH	Ec µs/cm	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
T	41	5.2	402	189	3	31	92	125
T	45	5.7	319	127	3	30	82	94
T	49	5.7	320	92	2	32	45	111
V	41	4.8	656	370	13	61	166	202
V	45	5.7	245	104	3	28	67	75
V	49	5.7	329	97	3	44	37	127
W	41	4.9	564	304	5	49	130	176
W	45	5.6	309	134	2	43	76	107
W	49	5.7	313	88	2	40	51	108
X	41	5.4	278	81	3	26	990	78
X	45	6.0	241	44	3	30	25	87
X	49	5.7	391	102	2	51	36	160
Y	41	5.5	391	107	5	23	1630	85
Y	45	5.8	248	64	2	36	30	88
Y	49	5.8	408	32	2	39	15	81
Z	41	5.3	339	115	6	28	74	106
Z	45	5.8	310	107	4	34	48	111
Z	49	5.7	233	106	2	56	46	164

Treatments

Standard temperature regime:

4.8 W/m² (2000 lux) throughout S.D.

T Low feed
V Standard feed
W High feed

12 W/m² (5000 lux) weeks 1-3 of S.D.

X Low feed
Y Standard feed
Z High feed

Table 18: Nutrition Observation Trial - Compost Analyses

Variety: Dark Yellow Boaldi Sample: 2 (week 8 of S.D.)

Treatment	Sticking Date (week no)	pH	Ec µs/cm	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
T	41	4.9	453	226	2	16	138	112
T	45	5.7	316	127	4	11	46	108
T	49	6.0	219	106	2	17	57	59
V	41	4.6	790	442	4	29	247	209
V	45	5.4	299	136	1	10	37	103
V	49	5.7	324	166	1	26	32	110
W	41	4.7	590	325	3	19	231	144
W	45	5.5	264	139	1	14	60	86
W	49	5.8	333	139	1	38	21	133
X	41	5.5	327	148	1	17	90	82
X	45	5.5	422	223	0	23	56	164
X	49	5.8	326	151	2	21	61	105
Y	41	5.4	417	190	1	20	67	121
Y	45	5.6	398	130	0	30	26	163
Y	49	6.0	286	109	2	18	30	103
Z	41	5.5	294	132	1	13	49	48
Z	45	5.4	413	193	0	18	74	134
Z	49	5.7	487	236	2	20	59	173

Treatments

Standard temperature regime:

4.8 W/m² (2000 lux) throughout S.D.

T Low feed
V Standard feed
W High feed

12 W/m² (5000 lux) weeks 1-3 of S.D.

X Low feed
Y Standard feed
Z High feed

Table 19: Nutrition Observation Trial - Compost Analyses

Variety: Dark Yellow Boaldi Sample: End of shelf life
Marketing stage: 2

Treatment	Sticking Date (week no)	pH	Ec µs/cm	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
T	41	5.1	596	279	3	17	83	185
T	45	6.4	234	82	2	5	36	56
T	49	6.0	233	111	2	9	47	67
V	41	4.8	641	323	3	20	141	191
V	45	5.8	307	139	2	9	29	93
V	49	5.7	349	174	1	19	31	115
W	41	4.9	465	232	3	7	124	114
W	45	5.8	240	115	1	10	44	62
W	49	6.0	267	155	3	13	25	105
X	41	5.6	297	76	2	9	25	90
X	45	6.3	221	101	3	7	36	44
X	49	5.9	357	176	2	7	34	116
Y	41	5.8	138	50	3	5	31	23
Y	45	6.2	240	69	3	9	26	64
Y	49	6.2	296	125	1	11	36	98
Z	41	5.7	276	102	3	8	30	78
Z	45	6.6	101	14	3	7	17	16
Z	49	5.6	511	68	1	9	54	176

Treatments

Standard temperature regime:

4.8 W/m² (2000 lux) throughout S.D.

T Low feed
V Standard feed
W High feed

12 W/m² (5000 lux) weeks 1-3 of S.D.

X Low feed
Y Standard feed
Z High feed

Table 20: Nutrition Observation Trial - Compost Analyses

Variety: Dark Yellow Boaldi Sample: End of shelf life
Marketing stage: 3

Treatment	Sticking Date (week no)	pH	Ec µs/cm	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
T	41	5.2	349	164	4	11	66	88
T	45	6.2	294	112	3	11	53	70
T	49	5.9	265	110	1	15	34	82
V	41	4.9	492	253	5	9	120	129
V	45	5.8	296	138	2	13	35	82
V	49	5.9	264	124	3	17	28	86
W	41	5.0	441	230	5	8	16	42
W	45	5.9	240	94	3	11	41	64
W	49	5.9	295	138	3	21	33	110
X	41	5.7	162	50	2	8	15	42
X	45	6.8	-	72	8	6	-	-
X	49	5.9	212	112	1	13	65	53
Y	41	5.9	278	54	3	8	27	40
Y	45	6.4	527	34	2	7	27	51
Y	49	6.2	206	91	1	10	26	60
Z	41	5.8	190	70	3	6	40	39
Z	45	6.3	213	55	2	9	36	44
Z	49	5.9	302	272	0	7	25	97

Treatments

Standard temperature regime:

4.8 W/m² (2000 lux) throughout S.D.

T Low feed
V Standard feed
W High feed

12 W/m² (5000 lux) weeks 1-3 of S.D.

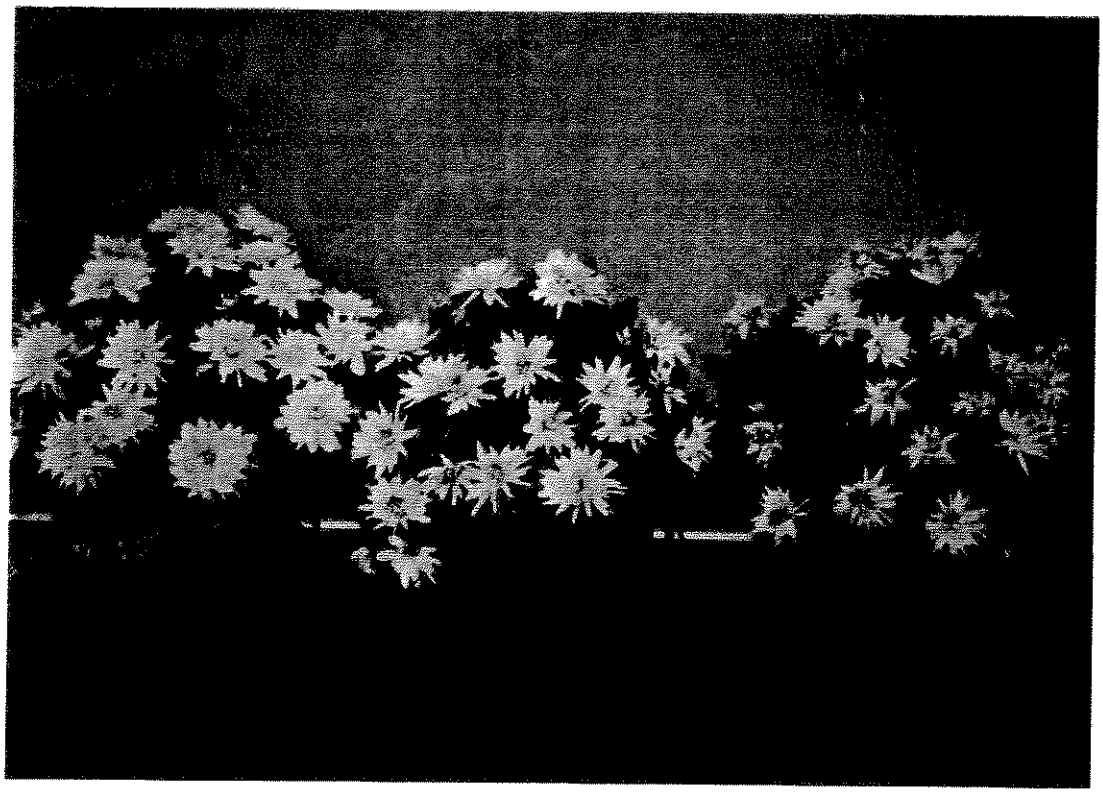
X Low feed
Y Standard feed
Z High feed

APPENDIX VI

Photographic Records

Plate 1

Illustration of deterioration scores for shelf-life assessments for the variety Charm



1 2 3

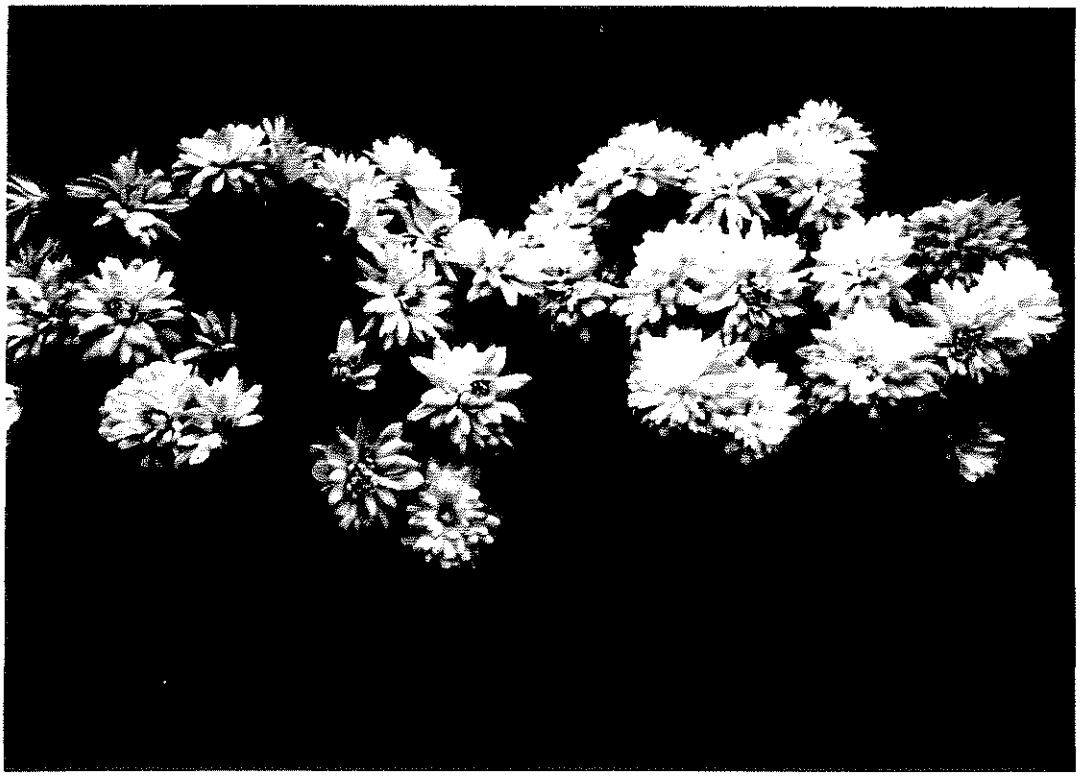
Key

1 = Minor deterioration of the overall pot
2 = Moderate deterioration of the overall pot
3 = Severe deterioration of the overall pot

Plate 2

Illustration of flower opening scores for shelf-life assessments for the variety Charm

Stage 3



Stage 4 Stage 5

Plate 3

Illustration of severe leaf damage

Plate 4

Main trial: Influence of supplementary lighting and DROP treatments on winter quality

Charm (week 45)

A B C D

2000 lux supplementary lighting throughout S.D.

E F G H J

5000 lux supplementary lighting weeks 1, 2 and 3 S.D.

DROP Treatments

A/E Standard temperature regime (18/18°C)
B/F DROP weeks 1, 2 and 3 of S.D.
C/G DROP week 4 of S.D. to marketing
D/H DROP throughout S.D.
J Standard temperature regime (18/18°C) + Alar

Plate 5

Main trial: Influence of supplementary lighting and DROP treatments on winter quality

Dark Yellow Boaldi (week 45)

A B C D

2000 lux supplementary lighting throughout S.D.

E F G H J

5000 lux supplementary lighting weeks 1, 2 and 3 S.D.

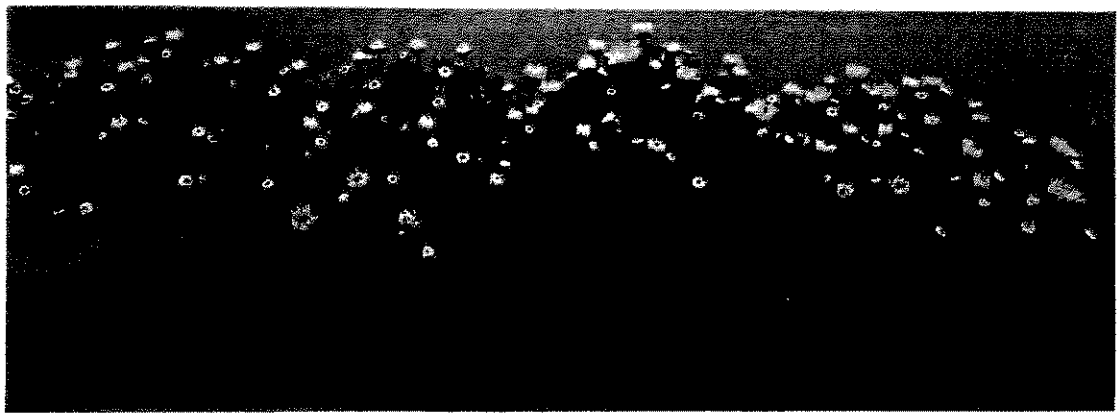
DROP Treatments

A/E Standard temperature regime (18/18°C)
B/F DROP weeks 1, 2 and 3 of S.D.
C/G DROP week 4 of S.D. to marketing
D/H DROP throughout S.D.
J Standard temperature regime (18/18°C) + Alar

Plate 6

Main trial: Influence of supplementary lighting and DROP treatments on winter quality

Miramar (week 45)



A B C D

2000 lux supplementary lighting throughout S.D.

E F G H J

5000 lux supplementary lighting weeks 1, 2 and 3 S.D.

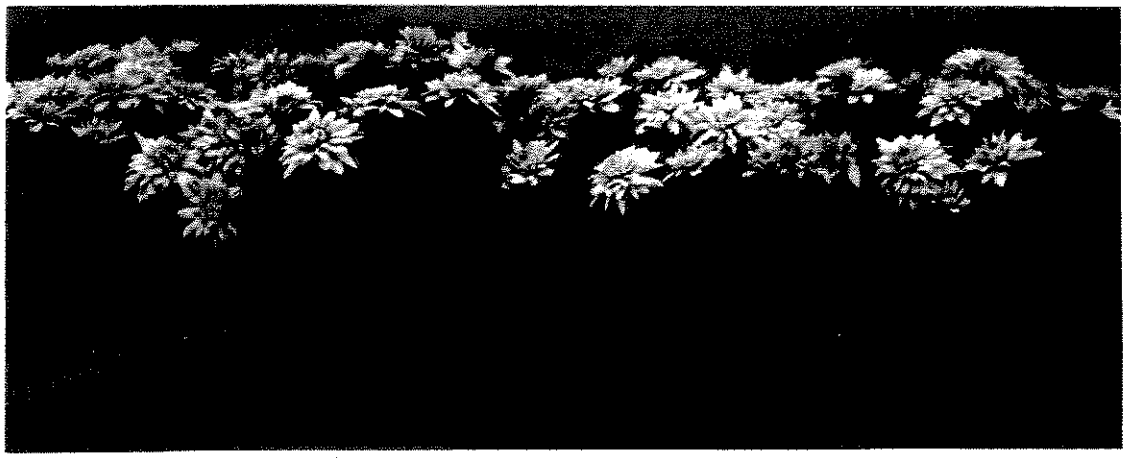
DROP Treatments

A/E Standard temperature regime (18/18°C)
B/F DROP weeks 1, 2 and 3 of S.D.
C/G DROP week 4 of S.D. to marketing
D/H DROP throughout S.D.
J Standard temperature regime (18/18°C) + Alar

Plate 7

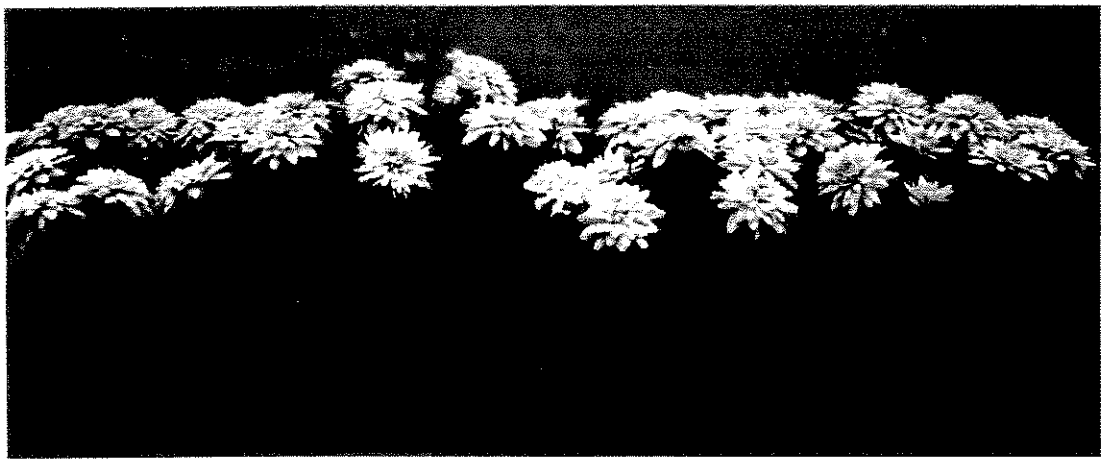
Observation trial

Charm (week 45)



A M D N

2000 lux supplementary lighting throughout S.D.



E O H P

5000 lux supplementary lighting weeks 1, 2 and 3 S.D.

DROP/Spacing Treatments

A/E Standard temperature regime (18/18°C), standard spacing
M/O Standard temperature regime (18/18°C), close spacing
D/H DROP throughout S.D., standard spacing
N/P DROP throughout S.D., close spacing

Plate 8

Observation trial

Dark Yellow Boaldi (week 45)

A M D N

2000 lux supplementary lighting throughout S.D.

E O H P

5000 lux supplementary lighting weeks 1, 2 and 3 S.D.

DROP/Spacing Treatments

A/E Standard temperature regime (18/18°C), standard spacing
M/O Standard temperature regime (18/18°C), close spacing
D/H DROP throughout S.D., standard spacing
N/P DROP throughout S.D., close spacing

Plate 9

Observation trial

Miramar (week 45)

A M D N

2000 lux supplementary lighting throughout S.D.

E O H P

5000 lux supplementary lighting weeks 1, 2 and 3 S.D.

DROP/Spacing Treatments

A/E Standard temperature regime (18/18°C), standard spacing
M/O Standard temperature regime (18/18°C), close spacing
D/H DROP throughout S.D., standard spacing
N/P DROP throughout S.D., close spacing

APPENDIX VII

Economic appraisal of lighting treatments

COST OF SUPPLEMENTARY LIGHTING FOR POT MUMS

Assumptions (Using capital costs, interest rates and electricity costs as in reports PC13b, 1991/92 and PC13c, 1992/93)

1. Capital cost of 400W SON/T lamp and installation = £160.

2. Illuminance 5000 lux 1 lamp covers $6m^2$.
   2000 lux 1 lamp covers 14 m^2.

3. Annual capital cost per luminare assuming amortized over 5 years at 14%

$$\frac{£160}{5 \text{ yrs}} + \left(\frac{80}{100} \times 14\%\right) = £43.20$$

4. Annual capital cost per m^2

$$@ \text{ 5000 lux} = \frac{43.2}{6} = £7.20/m^2/\text{year}$$

$$@ \text{ 2000 lux} = \frac{43.2}{14} = £3.09/m^2/\text{year}$$

5. S.D. lighting for 11 hours/day.

6. Spacings

Standard	L.D.	41 pots/m^2 (2 weeks)
	S.D. Intermediate	24 pots/m^2 (2 weeks)
	S.D. Final	12.5 pots/m^2
Close	L.D.	41 pots/m^2 (2 weeks)
	S.D. Intermediate	30 pots/m^2 (2 weeks)
	S.D. Final	15 pots/m^2

7. Lighting period October-February = 20 weeks.

Trial period = 20 weeks. Commercial winter production period = 26 weeks. Hence calculations are based on commercial standard of 26 weeks.

8. Electricity running costs

Standard	7 am - midnight	7.78 p/kW hr
Off-peak	Midnight - 7 am	2.61 p/kW hr

Each luminare requires 0.44 kW per hour ie. 400 watts per lamp plus 40 watts for starter equipment.

Standard spacing

A. Capital cost

a. S.D. @ 5000 lux for 3 weeks, two weeks of which are at intermediate spacing (24 pots/m^2)

with a further week at final spacing (12.5 pots/m^2)

at intermediate 1 m^2 will service 13 crops at 24 pots/m^2 = 312 pots

Capital cost = $\frac{720}{312}$ = 2.3 p/pot

at final spacing 1 m^2 will service 26 crops (if mobile) at 12.5 pots/m^2 = 325 pots

Capital cost = $\frac{720}{325}$ = 2.2 p/pot

Total Capital Cost = 2.3p + 2.2p = 4.5 p/pot

Note: 26 crops can be lit at final spacing only if mobile benches or mobile lights are used. Since it would be uneconomic to respace elsewhere the following spacing schedule gives a similar capital cost per pot without respacing.

[@ 5000 lux for 3 weeks at intermediate spacing 18 pots/m^2]
at intermediate spacing 1 m^2 will service 9 crops at 18 pots/m^2 = 162 pots

Capital cost = $\frac{720}{162}$ = 4.4 p/pot

b. S.D. @ 2000 lux throughout for 2 weeks at intermediate spacing (24 pots/m^2)

for 6 weeks at final spacing (12.5 pots/m^2)

Calculations assume 8 week response from start of short days to flower when provided with supplementary lighting.

at intermediate spacing 1 m^2 will service 13 crops at 24 pots/m^2 = 312 pots

Capital cost = $\frac{309}{312}$ = 1.0 p/pot

at final spacing 1 m^2 will service 4 crops at 12.5 pots/m^2 = 50 pots

Capital cost = $\frac{309}{50}$ = 6.2 p/pot

Total Capital Cost = 1.0 + 6.2 = 7.2 p/pot

B. Running cost

a. S.D. @ 5000 lux for 3 weeks

$$\frac{0.44 \text{ kW} \times 11 \text{ hrs} \times 14 \text{ days} \times 7.78 \text{ p/kW hr}}{6 \text{ m}^2} = 87.9 \text{ p/m}^2$$

@ 24 pots/m^2 at intermediate spacing for 2 weeks

Running cost per pot $= \frac{87.9}{24} = 3.7$ p/pot

$$+ \quad \frac{0.44 \text{ kW} \times 11 \text{ hrs} \times 7 \text{ days} \times 7.78 \text{ p/kW hr}}{6 \text{ m}^2} = 43.9 \text{ p/m}^2$$

@ 12.5 pots/m^2 at final spacing for 1 week

Running cost per pot $= \frac{43.9}{12.5} = 3.5$ p/pot

Total Running Cost $= 3.7 + 3.5 = 7.2$ p/pot

Alternatively:

$$\frac{0.44 \text{ kW} \times 11 \text{ hrs} \times 21 \text{ days} \times 7.78 \text{ p/kW hr}}{6 \text{ m}^2} = 131.8 \text{ p/m}^2$$

@ 18 pots/m^2 at intermediate spacing for 3 weeks

Running cost per pot $= \frac{131.8}{18} = 7.3$p/pot

b. S.D. @ 2000 lux throughout 2 weeks at 24 pots/m^2

plus 6 weeks at 12.5 pots/m^2

$$\frac{0.44 \text{ kW} \times 11 \text{ hrs} \times 14 \text{ days} \times 7.78 \text{ p/kW hr}}{14 \text{ m}^2} = 37.7 \text{ p/m}^2$$

@ 24 pots/m^2 at intermediate spacing for 2 weeks

Running cost per pot $= \frac{37.7}{24} = 1.6$ p/pot

$$+ \quad \frac{0.44 \text{ kW} \times 11 \text{ hrs} \times 42 \text{ days} \times 7.78 \text{ p/kW hr}}{14 \text{ m}^2} = 113.0 \text{ p/m}^2$$

@ 12.5 pots/m^2 at final spacing for 6 weeks

Running cost per pot $= \frac{113.0}{12.5} = 9.0$ p/pot

Total Running Cost $= 1.6$p $+ 9.0$ p $= 10.6$ p/pot

Close spacing

A. Capital cost

a. S.D. @ 5000 lux for 3 weeks, two weeks of which are at intermediate spacing (30 pots/m^2)

with a further week at final spacing (15 pots/m^2)

at intermediate 1 m^2 will service 13 crops at 30 pots/m^2 = 390 pots

Capital cost = $\frac{717}{390}$ = 1.8 p/pot

at final spacing 1 m^2 will service 26 crops (if mobile) at 15 pots/m^2 = 390 pots

Capital cost = $\frac{717}{390}$ = 1.8 p/pot

Total Capital Cost = 1.8p + 1.8p = 3.6 p/pot

Note: 26 crops can be lit at final spacing only if mobile benches or mobile lights are used. Since it would be uneconomic to respace elsewhere the following spacing schedule gives a similar capital cost per pot without respacing.

[@ 5000 lux for 3 weeks at intermediate spacing 22.5 pots/m^2]
at intermediate spacing 1 m^2 will service 9 crops at 22.5 pots/m^2 = 202.5 pots

Capital cost = $\frac{717}{202.5}$ = 3.5 p/pot

b. S.D. @ 2000 lux throughout for 2 weeks at intermediate spacing (30 pots/m^2)

for 6 weeks at final spacing (15 pots/m^2)

Calculations assume 8 week response from start of short days to flower when provided with supplementary lighting.

at intermediate spacing 1 m^2 will service 13 crops at 30 pots/m^2 = 390 pots

Capital cost = $\frac{307}{390}$ = 0.8 p/pot

at final spacing 1 m^2 will service 4 crops at 15 pots/m^2 = 60 pots

Capital cost = $\frac{307}{60}$ = 5.1 p/pot

Total Capital Cost = 0.8 + 5.1 = 5.9 p/pot

B. Running cost

a. S.D. @ 5000 lux for 3 weeks

$$\frac{0.44 \text{ kW} \times 11 \text{ hrs} \times 14 \text{ days} \times 7.78 \text{ p/kW hr}}{6 \text{ m}^2} = 87.9 \text{ p/m}^2$$

@ 30 pots/m^2 at intermediate spacing for 2 weeks

Running cost per pot $= \frac{87.9}{30} = 2.9$ p/pot

$$+ \quad \frac{0.44 \text{ kW} \times 11 \text{ hrs} \times 7 \text{ days} \times 7.78 \text{ p/kW hr}}{6 \text{ m}^2} = 43.9 \text{ p/m}^2$$

@ 15 pots/m^2 at final spacing for 1 week

Running cost per pot $= \frac{43.9}{15} = 2.9$ p/pot

Total Running Cost $= 2.9 + 2.9 = 5.8$ p/pot

Alternatively:

$$\frac{0.44 \text{ kW} \times 11 \text{ hrs} \times 21 \text{ days} \times 7.78 \text{ p/kW hr}}{6 \text{ m}^2} = 131.8 \text{ p/m}^2$$

@ 22.5 pots/m^2 at intermediate spacing for 3 weeks

Running cost per pot $= \frac{131.8}{22.5} = 5.9$p/pot

b. S.D. @ 2000 lux throughout 2 weeks at 30 pots/m^2

plus 6 weeks at 15 pots/m^2

$$\frac{0.44 \text{ kW} \times 11 \text{ hrs} \times 14 \text{ days} \times 7.78 \text{ p/kW hr}}{14 \text{ m}^2} = 37.7 \text{ p/m}^2$$

@ 30 pots/m^2 at intermediate spacing for 2 weeks

Running cost per pot $= \frac{37.7}{30} = 1.3$ p/pot

$$+ \quad \frac{0.44 \text{ kW} \times 11 \text{ hrs} \times 42 \text{ days} \times 7.78 \text{ p/kW hr}}{14 \text{ m}^2} = 113.0 \text{ p/m}^2$$

@ 15 pots/m^2 at final spacing for 6 weeks

Running cost per pot $= \frac{113.0}{15} = 7.5$ p/pot

Total Running Cost $= 1.3$p $+ 7.5$ p $= 8.8$ p/pot

C. Overall cost of treatment

		Cost (p/pot) Capital	Running	Total
a.	12 W/m² (5000 lux) weeks 1-3 of S.D.			
	Standard spacing (24 pots/m² weeks 1-2, 12.5 pots/m² week 3)	4.5	7.2	11.7
	Close spacing (30 pots/m² weeks 1-2, 15 pots/m² week 3)	3.6	5.8	9.4
	Alternatively:			
	Standard spacing (18 pots/m² weeks 1-3)	4.4	7.3	11.7
	Close spacing (23 pots/m² weeks 1-3)	3.5	5.9	9.4
b.	4.8 W/m² (2000 lux) throughout S.D.			
	Standard spacing (24 pots/m² weeks 1-2, 12.5 pots/m² week 3)	7.2	10.6	17.8
	Close spacing (30 pots/m² weeks 1-2, 15 pots/m² week 3)	5.9	8.8	14.7

Savings on total cost attributed to supplementary lighting treatment through the closer spacing densities assessed are therefore:

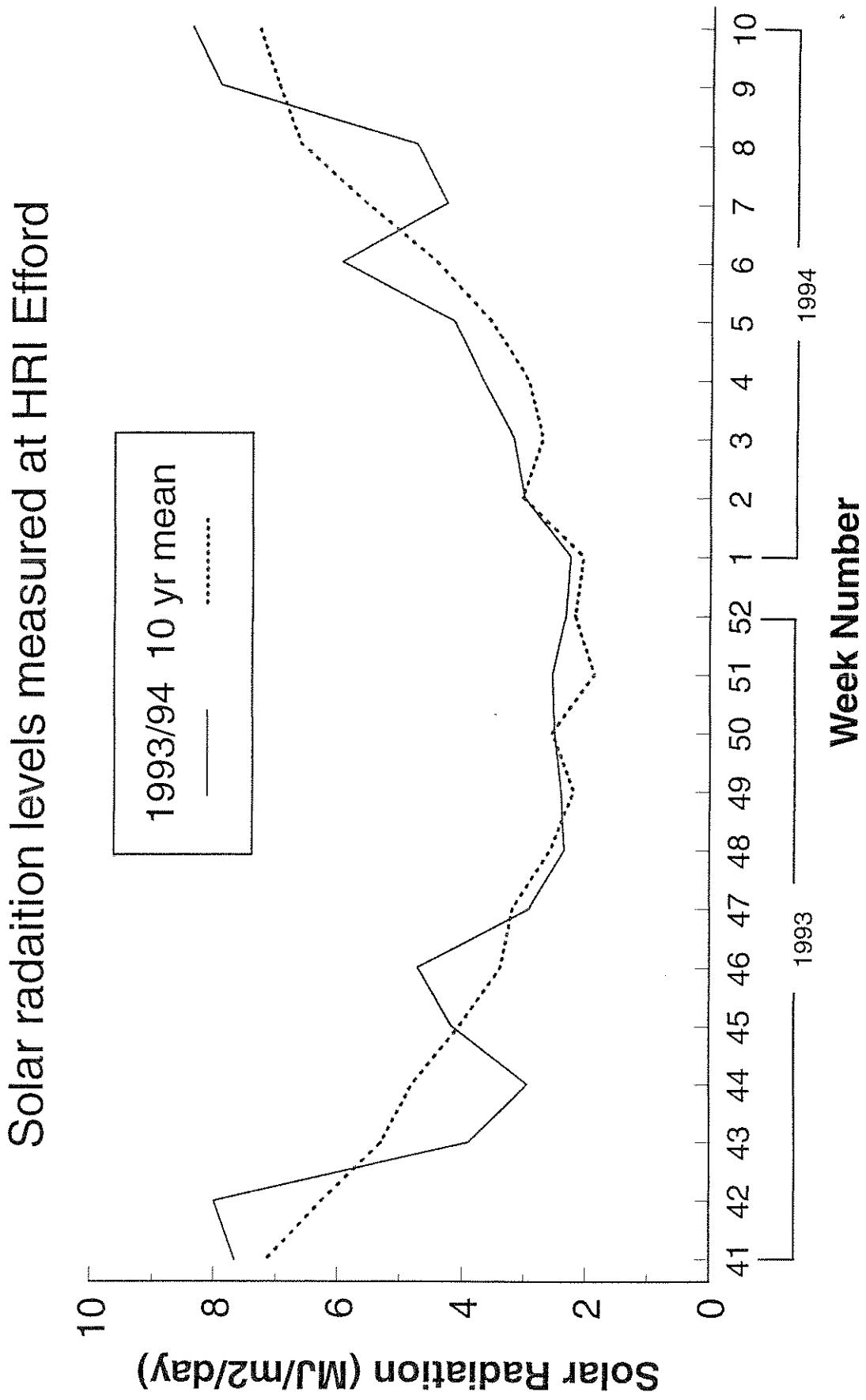
2.3 p/pot for 12 W/m² (5000 lux) supplementary lighting weeks 1-3 of S.D. (19.7%).

or

3.1 p/pot for 4.8 W/m² (2000 lux) supplementary lighting throughout S.D. (17.4%).

APPENDIX VIII

Solar radiation levels


Solar radaition levels measured at HRI Efford
1993/94
10 yr mean
Solar Radiation (MJ/m2/day)
0
2
4
6
8
10
41 42 43 44 45 46 47 48 49 50 51 52 1 2 3 4 5 6 7 8 9 10
1993
1994
Week Number

APPENDIX IX

Copy of Contract Terms and Conditions and Schedule

Contract between HRI (hereinafter called the "Contractor") and the Horticultural Development Council (hereinafter called the "Council") for a research/development project.

1. TITLE OF PROJECT

Contract No: PC92
Contract date: 4.11.93

CHRYSANTHEMUMS: THE COMBINED INFLUENCE OF SUPPLEMENTARY LIGHTING AND DIFFERENCE IN TEMPERATURE (DIF) ON WINTER QUALITY OF COMMERCIALLY GROWN VARIETIES OF POT MUMS.

2. BACKGROUND AND COMMERCIAL OBJECTIVE

High intensity supplementary lighting has become an established technique for quality production of pot chrysanthemums during the winter period since poor daylight would otherwise become a limiting factor, with reduction in growth rate and bud initiation, increased variability and prolonged production time with resultant decline in profits.

The most effective lighting regimes for improved winter quality of commercial pot mum varieties were established in trials funded through HDC at HRI Efford 1991/92 and 1992/93. These were:

i) Supplementary lighting at 5000 lux (12.0 w/m^2) for the first three weeks of short days.

ii) Supplementary lighting at 2000 lux (4.8 w/m^2) throughout short days.

Although quality was enhanced by these supplementary lighting regimes the economic benefits need to be further evaluated. In particular the possibility of producing quality pot mums at tighter spacing under supplementary lighting during the winter period could enhance profitability relative to production costs per unit area. Hence the influence of spacing on quality with particular reference to lower leaf quality needs to be examined.

In addition the influence of difference in temperature (DIF) as a method of growth regulation of pot chrysanthemums has stimulated much interest within the industry.

Trials to date at HRI Littlehampton and Efford have demonstrated the potential of negative DIF treatments as a method of height control. For winter production of pot mums it is important to be able to integrate this technique with that of supplementary lighting.

Hence the investigation outlined here proposes to examine the combined effects of DIF and supplementary lighting regimes on winter quality.

In addition the supplementary lighting regimes, in

particular 2000 lux throughout short days may influence the frequency of irrigation/nutrition and in turn may have a major impact on subsequent shelf life of the product. Hence additional observations will be carried out to examine the influence of nutritional regimes and their interaction with supplementary lighting on post production plant performance.

Thus the objectives are:

a) to evaluate the combined effects of supplementary lighting and DIF on winter quality of commercially grown varieties of pot mums.

b) to examine the interaction of pot spacing with supplementary lighting and DIF regimes and its effects on quality of product and economics of production.

c) to examine the influence of nutrition and its interaction with supplementary lighting regimes on plant performance under shelf life conditions.

3. POTENTIAL FINANCIAL BENEFIT TO THE INDUSTRY

The combined effects of high intensity supplementary lighting and DIF may be used to:-

a) ensure good production quality during the winter period.

b) potentially reduce use of growth regulants.

c) maximise potential space allocation by increasing cropping density and reducing cropping time which could enhance economic viability.

d) improve post-production shelf life qualities (and potentially reduce nutritional requirements).

All of these factors balanced with production costs could be used to maximise returns. A financial evaluation will be included in the final project report.

4. SCIENTIFIC/TECHNICAL TARGET OF THE WORK

The qualitative and quantitative influence of supplementary lighting, DIF, spacing and nutrition on winter production of pot chrysanthemums will be examined relative to plant form, rate and quantity of bud initiation, flowering uniformity, production time, growth regulation and post-production longevity (The latter will be carried out for the nutritional study only.)

5. CLOSELY RELATED WORK - COMPLETED OR IN PROGRESS

Related work within HRI examining DIF as a method of growth

regulation on a range of pot and bedding species forms part of an HDC-funded three year programme (PC41). Guidelines are also provided from American studies on cultural and post-production practices used for Yoder bred varieties.

6. DESCRIPTION OF THE WORK

a) Main trial - supplementary lighting/DIF

In examining the effectiveness and economics of DIF and supplementary lighting the following treatments will be compared.

Lighting regimes

i) Supplementary lighting at 2000 lux ($4.8W/m^2$) throughout short days (S.D)
ii) Supplementary lighting at 5000 lux ($12.0W/m^2$) for the first three weeks of short days

(Long days for 2 weeks without supplementary lighting)

Temperature regimes

i) Control, 18°C day, 18°C night
ii) Negative DIF during first three weeks of S.D.
iii) Negative DIF at final spacing (after first 3 weeks in S.D.)
iv) Negative DIF throughout S.D.

Supplementary lighting will be provided continuously by 400W high pressure sodium (SONT/T) lamps during short days for 11 hours from 0700 - 1800 hrs.

DIF regimes will be applied as 6°C drop for 3 hours at dawn (0700 - 1000) with temperature compensation to achieve 24 hour average of 18°C.

CO^2 will be applied in a conventional manner to standard regimes and to DIF regimes after the DIF period.

Chemical growth regulation

i) No Alar applied to main trial plots
ii) Alar applied 'as required' to additional plots 5000 lux non DIF regime "Commercial Standard".

Phosphon will not be added to growing media at sticking, and standard nutrition will be applied.

Varieties

i) Charm
ii) Dark Yellow Boaldi
iii) Miramar

Sticking dates

Weeks 41,45 and 49

Assessments

The effect of treatments on production time and plant quality will be assessed at conventional marketing stage by recording:

1. Time taken to reach marketable stage.
2. Uniformity of flower development.
3. Plant height - of 5 plants per pot.
4. Maximum and minimum plant spread per pot.
5. Leaf quality.
6. Growing media analyses four and eight weeks after start of short days.
7. Environmental and solar radiation measurements.
8. Photographic record as appropriate.

b) Observation trial - Spacing

In examining the influence of spacing density on plant quality and its interaction with supplementary lighting and DIF regimes the following treatments will be compared.

Lighting regimes
- i) Supplementary lighting at 2000 lux (4.8W/m^2 throughout short days (S.D.)
- ii) Supplementary lighting at 5000 lux (12.0W/m^2) for the first three weeks of short days

(Long days for 2 weeks without supplementary lighting)

Temperature regimes
- i) Control, 18°C day, 18°C night.
- ii) Negative DIF throughout S.D.

Spacing density
- i) Standard (Intermediate - 24/m^2, Final - 12.5/m^2)
- ii) Close (Intermediate - 30/m^2, Final - 15/m^2)

Varieties
- i) Charm
- ii) Dark Yellow Boaldi
- iii) Miramar

Sticking dates
Weeks 41,45 and 49

No alar would be applied in this observation and a standard nutrition regime would be followed.

Assessments

As for main trial.

c) Observation trial - Nutrition, plant performance and shelf life

An additional observation will be carried out to examine

the influence of nutritional regime on plant performance and shelf life qualities.

Nutritional regime

i) High
ii) Standard - as for main trial
iii) Low

Lighting regime

i) Supplementary lighting at 2000 lux (4.8W/m^2) throughout SD
ii) Supplementary lighting at 5000 lux (12W/m^2) for the first three weeks of SD.

Temperature regime

Control, 18°C day, 18°C night

Spacing density

Standard - as for main trial

Chemical growth regulation

i) No alar applied (2000 lux lighting regime only)
ii) Alar applied 'as required' (5000 lux lighting regime only)

Varieties

i) Charm
ii) Dark Yellow Boaldi

Sticking dates

Weeks 41, 45 and 49

Plant assessments

As for main lighting/DIF trial

Shelf life assessments

Plants selected at market stages:

i) Stage 2
ii) Stage 3

Stored in cool chamber for three days, sleeves removed after four days in shelf life environment and assessed for shelf life performance, including leaf quality at regular intervals over a four-week period.

Design details subject to final agreement.

7. COMMENCEMENT DATE AND DURATION

Start date 01.10.93; duration 1 year.

The experiments will be conducted during the growing season October '93 - March '94.

The results will be analysed during the summer and the final report will be produced by September 1994.

8. STAFF RESPONSIBILITIES

Project Leader:	Dr ~~Ruth Finlay~~ Debbie Wilson - HRI Efford
HDC Co-Ordinator:	Mr David Abbott - Swallowfield Nurseries

9. LOCATION

HRI Efford (E-Block) 6 Compartments
Plus Shelf life environment

10. COSTS

The costs for the trial, as detailed above, will be

11. PAYMENT

On each quarter day the Council will pay to the Contractor in accordance with the following schedule:

Quarter/Year	1993	1994
1	-	
2	-	
3	-	
4		-

Contract No: PC/92

TERMS AND CONDITIONS

The Council's standard terms and conditions of contract shall apply.

Signed for the Contractor(s)

Signature.....

Position..Commercial and Marketing Manager HRI

Date.....19/11/93.....

Signed for the Contractor(s)

Signature.....

Position.....

Date.....

Signed for the Council

Signature.....

Position.....CHIEF EXECUTIVE

Date.....5.11.93.....

APPENDIX X

References

Cockshull, K.E. and Hughes, A.P. 1972. Flower formation in Chrysanthemum morifolium - the influence of light level. Journal of Horticultural Science, 47, 113

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