HORTICULTURE RESEARCH INTERNATIONAL

EFFORD

Report to:

Horticultural Development Council
18 Lavant Street
PETERSFIELD
Hampshire
GU32 3EW

Tel: 0730 263736
Fax: 0730 265394

HRI Contract Manager:

Margaret A Scott
HRI Efford
LYMINGTON
Hampshire
SO41 0LZ

Tel: 0590 673341
Fax: 0590 671553

Period of investigation: October 1992 - March 1993
Date of issue of report: June 1994
No. of pages in report: 110
No. of copies of report: Six
This is copy no. 1: Issued to HDC

CONTRACT REPORT

Chrysanthemums: The influence of supplementary lighting on winter quality and shelf life of American bred varieties of pot 'mums

HDC PC13c
1992/93

PRINCIPAL WORKERS

HRI EFFORD

A R Finlay, BSc, PhD	Technical Officer
D P Wilson, BSc, PhD (Author of Report)	Technical Officer
Mrs S Fussell, BSc	Assistant Scientific Officer
Miss S Williams, BSc	Assistant Scientific Officer
Miss S Horsley	Assistant Scientific Officer
Mr C Vigor	Nursery Staff
Mr M Verran	Nursery Staff
Mr G Stancer	Nursery Staff
Mrs S Wilson	Nursery Staff

HRI LITTLEHAMPTON

Mr R Edmonson, MSc	Statistician

HDC CO-ORDINATOR

Mr D Abbott

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 ..... Margaret A. Scott

Margaret A Scott
Deputy Head of Station
Date ....8/6/94.....

Report authorised by .....
Signature

M R Shipway
Head of Station
HRI Efford
Lymington
Hants SO41 0LZ

Date ..8/6/94.....

CONTENTS

	Page
Relevance to Growers and Practical Application	
Application	i
Summary	i
Experimental Section	
Introduction	1
Objectives	2
Materials and Methods	3
Treatments - Main Trial	3
Treatments - Observation Trial	4
Growth Regulator Treatments	4
Design	4
Cultural details	6
Assessments	7
Statistical analyses	9
Results	10
Main trial - the influence of supplementary lighting on winter quality	10
Effect of supplementary lighting on production time	10
Effect of supplementary lighting on plant height	15
Effect of supplementary lighting on pot maximum and minimum spread	20
Effect of supplementary lighting on flower development	21
Assessment of the stage of marketing and its potential interaction with supplementary lighting on shelf life	26
Effect of supplementary lighting and stage of marketing on bud deterioration during shelf life	26
Effect of supplementary lighting and stage of marketing on bud expansion during shelf life	29

Observation trial - Combined influence of supplementary lighting and growth regulants on production time and plant form. 32

Effect of 2000 lux S.D. supplementary lighting and its interaction with growth regulants on production time 32

Effect of 2000 lux S.D. supplementary lighting and its interaction with growth regulants on plant height 33

Effect of 2000 lux S.D. supplementary lighting and its interaction with growth regulants on mean pot spread 34

Effect of 2000 lux S.D. supplementary lighting and its interaction with growth regulants on flower development 35

Compost and leaf analyses at marketing 36

Photographic records 36

Solar radiation 36

Discussion 37

Conclusions 39

Recommendations for further work 40

APPENDICES

Appendix I	Use of growth regulants - rates and dates of applications	41
Appendix II	Pot spacings	42
Appendix III	Main trial: Influence of Supplementary Lighting on Winter Quality - Tables of Results	43
Appendix IV	Main trial: Assessment of Marketing Stage and its Potential Interaction with Supplementary Lighting on Shelf Life - Tables of Results	54
Appendix V	Observation Trial: Combined Influence of Supplementary Lighting and Growth Regulants on Production Time and Plant Form - Table of Results	61
Appendix VI	Compost Analyses	66
Appendix VII	Leaf Analyses	88
Appendix VIII	Economic Evaluations	97
Appendix IX	Photographic Records	99
Appendix X	Solar Radiation Data	108
Appendix XI	Copy of Contract Terms and Conditions and Schedule	109
Appendix XII	References	110

FINAL REPORT JUNE 1994

HDC PC13c

Chrysanthemums: The influence of supplementary lighting on winter quality and shelf life of American bred varieties of pot 'mums

Dr A R Finlay
HRI Efford

Dr D P Wilson
HRI Efford

Co-ordinator: Mr D Abbott

Commenced: October 1992

Completed: March 1993

Key Words: Chrysanthemum, Supplementary Lighting, Shelf Life, Pot 'Mums

RELEVANCE TO GROWERS AND PRACTICAL APPLICATION

Application

Supplementary lighting regimes developed in previous trials (HDC PC 13b) were assessed on an extended range of American bred single and decorative varieties. The benefits recorded in previous supplementary lighting trials, including reductions in crop production time (most notably for the 5000 lux treatments) and also improvements in pot quality (with the 2000 lux treatment), were also achieved with both the single and decorative varieties assessed in the current trial.

Shelf life studies were also carried out to examine the impact of lighting regime and stage of marketing on visual pleasure of the product. Supplementary lighting treatments had no significant influence over performance of plants in shelf life. Marketing stage, however, had a significant influence on shelf life and marketing pots at a more advanced stage than for conventional practice produced a pot which gave greater visual pleasure at marketing with no significant reductions in shelf life.

Summary

i) Background and trial details

Even in the most favoured areas of the British Isles there are three months of winter when light values are below the minimum for satisfactory growth of chrysanthemums. Poor winter daylight reduces the rate of growth and affects the rate of bud initiation, hence the cropping time and variability of the product increases with resultant declines in income. Flowering uniformity, overall quality and speed of production can be improved by supplementary lighting but this needs to be balanced with capital investment, running costs and optimisation of space.

The influence of supplementary lighting on quality of pot chrysanthemums produced during the winter period has been the subject of numerous trials principally at the Lee Valley EHS and latterly at HRI Efford. Suitable lighting schedules for Princess Anne types were initially identified, and later studies illustrated the benefits of supplementary lighting on decorative American bred varieties. Potential to extend the market range exists however if single varieties could be successfully grown during the winter period. This could only be achieved if these varieties responded positively to supplementary lighting during winter and under comparable conditions to those used for production of decorative types. It is also important to determine the influence of any production techniques on end product performance in order to ensure popularity in the market place.

In addition to varietal response to supplementary lighting regimes, the stage at which the

are marketed in relatively tight bud, but better shelf life and quality may be achieved if marketing takes place at a later stage.

The objectives of the current project were therefore as follows:

i) to evaluate the potential benefits of supplementary lighting for winter production of a range of American bred single and decorative varieties,

ii) to examine the influence of these lighting regimes on shelf-life qualities,

iii) to assess the influence of stage of marketing on plant performance under shelf life conditions.

Additional observation studies were included to examine the influence of lighting at 2000 lux throughout the short day period on plant height, and its interaction with plant growth regulants.

The supplementary lighting treatments compared were as follows:

Long Days (2 weeks propagation)	**Short Days**
No Supplementary Lighting	No Supplementary Lighting
No Supplementary Lighting	Supplementary lighting at 2000 lux throughout
No Supplementary Lighting	Supplementary lighting at 5000 lux during weeks 1, 2 and 3
Supplementary Lighting at 5000 lux during second week	Supplementary lighting at 5000 lux during weeks 1 and 2
No Supplementary Lighting	Supplementary lighting at 5000 lux during weeks 1 and 2

Production time and plant quality were examined under these lighting regimes with three decorative varieties (Charm, Dark Yellow Boaldi and Yuba) and three single varieties (Davis, Miramar and Tan) on three separate occasions during the winter period (i.e. sticking in week 41, week 45 and week 49). The time taken to reach marketing stage, flower production and

uniformity of development, plant height and pot spread were assessed at a standard marketing stage (stage 2, defined below).

The effect of supplementary lighting and stage of marketing on shelf life was assessed with two decorative and two single varieties (Charm, Dark Yellow Boaldi, Miramar and Tan) for the same sticking dates as specified above. Plants were selected at marketing stages 1, 2 and 3 as defined below:

Stage 1	**Stage 2**	**Stage 3**
7-12 flowers showing colour 7 flowers with petals 10mm long and upright	7-12 flowers showing colour 7 flowers with petals 20mm long and bending outwards	12 flowers all just bending outwards, 50% of petals at least 20mm long

Marketing was simulated by sleeving the pots, placing them in boxes and storing in a dark cool chamber (5-6^{0}C) for two days. Plants were then transferred to an environment of 18-20°C lit at 1000 lux using fluorescent lamps for 12 hours per day. Sleeves were removed one day later and shelf life performance including uniformity of flower opening and flower deterioration was assessed at regular intervals over a four week period.

Treatments included in the observation trial were as follows:

Long Days (2 weeks propagation)	**Short Days**
No Supplementary Lighting	No Supplementary Lighting
No Supplementary Lighting	Supplementary lighting at 2000 lux throughout

Two varieties were grown in this observation trial. Firstly Yuba was compared under both lighting regimes with and without Phosphon added to the compost. Secondly, Charm was grown under both regimes with and without Alar applications.

ii) Results

All of the short day supplementary lighting regimes assessed reduced the production time of both the single and decorative varieties grown in comparison with unlit crops. The greatest savings in production time (of up to 7.9 days) were achieved using supplementary lighting at 5000 lux

for the first three weeks of short days. All lighting regimes were most effective in this respect during the mid winter period (i.e. sticking in weeks 45 and 49) when solar radiation levels for bud initiation were lowest.

Smaller savings in production time (up to 4 to 5 days during the mid winter period) were achieved with supplementary lighting at 2000 lux throughout short days, and quality improvements were also noted. In particular plants were more compact under this lighting regime with darker green foliage and a higher total number of buds.

Where a total of three weeks supplementary lighting was supplied as 5000 lux in the second week of long days and the first two weeks of short days, production time was slightly longer or comparable to that of plants which had only two weeks at 5000 lux at the start of short days. All 5000 lux lighting regimes increased plant height and this effect was further enhanced by commencing lighting in the second week of long days. There were no significant increases in the production of total buds associated with the lighting regime commencing in long days although this regime did yield benefits in terms of increasing the number of expanding buds at stages 3 and 4 (expanding) by the standard marketing stage.

No significant differences in shelf life performance were recorded between plants grown under the different lighting regimes assessed. Marketing stage however significantly influenced performance of plants in shelf life. Records of number of buds at different opening stages (as defined by Cockshull and Hughes, 1972) and number of buds at each of three deterioration stages were combined into a bud opening score and a bud deterioration score respectively. It was then possible to illustrate statistically the clear visual observations that when plants were selected for marketing in tight bud (Stage 1), subsequent flower development was severely restricted. Flowers failed to open fully and petals were distorted or discoloured depending on variety. In contrast, plants selected in a more advanced state (Stage 3), displayed fully expanded flowers with good colour at marketing. Furthermore shelf life was not reduced by this later stage of marketing.

To convey this message to growers, wholesalers, distributors, florists and ultimately the consumer, members of the National Pot Mum Study Group, in discussion with HDC and HRI, agreed to develop and fund a publicity poster on the impact of winter marketing stage on shelf life qualities and the risks of premature marketing.

iii) Application

In summary, the most effective supplementary lighting regimes for improved winter quality of American bred single and decorative pot mum varieties were established as:

i) Supplementary lighting at 5000 lux for the first three weeks of short days - (with savings in production time of up to 7.9 days).

ii) Supplementary lighting at 2000 lux throughout short days - (for enhanced pot quality and savings in production time of up to 4 to 5 days).

The suitability of the supplementary lighting regimes assessed would need to be assessed against the increase in costs (i.e. 11.7p per pot for i, and 14.9 p per pot for ii, based on economic evaluations calculated in HDC Project Report PC 13b and reproduced in Appendix VII), and the type of pot required by individual marketing outlets. It is clear that whichever lighting regime is adopted for the winter grown crop, marketing pots at a more advanced state in winter than has been conventionally accepted will enhance the visual pleasure to the customer and will not decrease shelf life.

INTRODUCTION

Even in the most favoured areas of the British Isles there are three months of the winter when light values are below the minimum for satisfactory growth of chrysanthemums. Poor winter daylight reduces the rate of growth and affects the rate of bud initiation, hence the cropping time and variability of the product increases with resultant decline in profits. Flowering uniformity, overall quality and rate of production can be improved by supplementary lighting, however this needs to be balanced with capital investment, running costs and optimization of space allocation.

The influence of supplementary lighting on quality of pot chrysanthemums produced during the winter period has been the subject of numerous trials principally at the Lee Valley EHS and latterly at HRI Efford. Lighting schedules were developed primarily for Princess Anne types but, with the increasing popularity of American bred varieties and the decline in the market dominance of Princess Anne types, there remained a need to evaluate the benefits of supplementary lighting on winter production of these varieties.

Trials to date at HRI Efford have concentrated on improved production of decorative types of American bred varieties. Potential to extend the market exists if single American bred varieties could be successfully grown during the winter period. This could only be achieved if these varieties responded positively to supplementary lighting during winter and under comparable conditions to those used for production of decorative types.

In addition, varietal response to supplementary lighting regimes, and the stage at which the product is marketed, may have a major impact on subsequent shelf life of the product. In the UK, plants are marketed in relatively tight bud, but better shelf life may be achieved if marketing takes place at a later stage.

The 1992/93 study therefore examined the effects of supplementary lighting on a range of decorative and single American bred varieties along with the influence of marketing stage on shelf life.

OBJECTIVES

The objectives were:

Main Trial:

a) To evaluate the potential benefit of supplementary lighting for winter production of a range of American bred single and decorative varieties.

b) To examine the influence of these lighting regimes on shelf life qualities.

c) To assess the influence of stage of marketing on plant performance under shelf life conditions.

Observation Trial: To examine the influence on plant height of lighting at 2000 lux throughout the short day period and its interaction with the use of growth regulants.

MATERIALS AND METHODS

Treatments - Main Trial

The following supplementary lighting regimes were compared:

	Long days (2 weeks propagation)	Short days
a.	No supplementary lighting	No supplementary lighting throughout
b.	No supplementary lighting	Supplementary lighting at 2000 lux (4.8 W/m^2) throughout
c.	No supplementary lighting	Supplementary lighting at 5000 lux (12 W/m^2) during weeks 1, 2 and 3
d.	Supplementary lighting at 5000 lux (12 W/m^2) during second week	Supplementary lighting at 5000 lux (12 W/m^2) during weeks 1 and 2
e.	No supplementary lighting	Supplementary lighting at 5000 lux (12 W/m^2) during weeks 1 and 2

Supplementary lighting was provided by 400 W high pressure sodium (SONT) lamps, during long days for 24 hours/day and during short days for 11 hours from 0700-1800.

Varieties

Decorative	Charm
	Dark Yellow Boaldi
	Yuba
Single	Davis
	Miramar
	Tan
Sticking Dates	Week 41
	Week 45
	Week 49

Treatments - Observation Trial

	Long days (2 weeks propagation)	Short days
a.	No supplementary lighting	No supplementary lighting throughout
b.	No supplementary lighting	Supplementary lighting at 2000 lux (4.8 W/m²) throughout

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

Varieties Yuba
Charm

Sticking dates Week 41
Week 45
Week 49

Growth regulator treatments

For each lighting treatment a) and b) regulants were applied as follows:

A.	Effect of alar	+/-	Yuba
P.	Effect of phosphon	+/-	Charm

Design

Main Trial - Supplementary lighting

5	lighting treatments
x	
1	plot per lighting treatment
x	
6	varieties
x	
3	sticking dates
—	
90	plots
—	

Main Trial - Supplementary lighting and marketing stage on shelf life

5	lighting treatments
x	
1	plot per lighting treatment
x	
4	varieties
x	
3	sticking dates
x	
3	marketing stages
180	plots in shelf life

Observation Trial - Supplementary lighting at 2000 lux throughout SD and its interaction with the use of growth regulants.

2	lighting treatments
x	
2	growth regulator treatments
x	
1	plot per treatment
x	
2	varieties
x	
3	sticking dates
24	plots

One plot = 30 pots (5 rows, 6 pots per row, staggered spacing)
5 plants per pot
10 pots per plot fully guarded and recorded

One plot = (Shelf life) 4 pots per marketing stage
5 plants per pot
4 pots per plot recorded

Cultural details

i. Plant material

Cuttings were purchased from Yoder Toddington Ltd.

ii. Propagation (Long Days)

Cuttings were potted into Fisons Levington M2 in 140 mm 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 approximately 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 100 lux tungsten lamps (8 minutes on, 8 minutes off cycle). Since the supplementary lighting treatment during long days remained on for 24 hours, these plants were exposed to cyclic lighting for the first week of long days only.

iii. Short Day environment

The temperature regime was set at 18°C day and night with ventilation at 21°C and thermal screen cover from 18.00 to 07.00.

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

iv. Growth regulation

Plants were pinched at approximately 7 leaves. Chemical growth regulators, chlorophonium chloride (Phosphon) and daminozide (Alar) were applied as appropriate according to variety and stage of development (Appendix I, page 41).

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 (Appendix II, page 42).

vi. Nutrition

Liquid feeding commenced at the start of short days and continued with every watering. The feed supplied N, P, K as 300 mg/l N, 60 mg/l P_2O_5 (26 mg/l P) and 250 mg/l K_2O (207 mg/l K).

vii. Pest and disease control

A routine spray programme was maintained throughout the life of the trial. Pesticides included aldicarb (Temik), mancozeb (Karamate Dry Flo), iprodione (Rovral), deltamethrin (Decis), malathion (MTM Malathion 60), endosulfan (Thiodan) and dichlorvos (Nuvan 500 EC).

vii. Shelf life environment

Plants of the varieties, Charm, Dark Yellow Boaldi, Miramar and Davis were selected at marketing stage 0/1, 2 and 3 as identified by Yoder Bros. Inc (See Plate 1, Appendix IX). To simulate marketing conditions, plants were sleeved, boxed and stored in a cool chamber (approximately 5-6°C) for 2 days. Plants were then removed from boxes and transferred to an environment of 18-20°C lit at 1000 lux using fluorescent lamps for 12 hours per day. Sleeves were removed after 1 day in this environment and plants were watered as necessary with plain water.

Assessments

A. The effect of supplementary lighting treatments on production time and plant quality for all six varieties was assessed at standard marketing stage by recording:

i. Time taken to reach standard marketable stage (i.e. 7-12 flowers showing colour, 7 flowers with petals 20mm long and bending outwards).

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

iii. Plant height from stem base to tallest flower.

iv. Maximum and minimum plant spread per pot.

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

vi. Foliage analyses at standard marketing stage.

vii. Environmental and solar radiation measurements.

B. The effect of stage of marketability and potential interaction with influence of supplementary lighting treatments was assessed on the varieties, Charm, Dark Yellow Boaldi, Miramar and Davis in the shelf life environment. Records of the following parameters were taken at the start of shelf life (i.e. when pots had been removed from cold store and sleeves were taken off) and then regularly over a four week period in this environment.

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

ii. Stage of bud deterioration recorded in the categories, D1 - slightly deteriorated (ie. discoloration and/or bud distortion on opening), D2 - moderately deteriorated, D3 - severely deteriorated, dead.

iii. Growing media analyses at the end of shelf life.

iv. Photographic records.

C. The effect of supplementary lighting at 2000 lux throughout S.D. and its interaction with the use of growth regulants on Yuba and Charm was assessed at standard marketing stage by recording:

i. Time taken to reach marketable stage (i.e. 7-12 flowers showing colour, 7 flowers with petals 20mm long and bending outwards).

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

iii. Plant height from stem base to tallest flower.

iv. Maximum and minimum plant spread per pot.

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

vi. Foliage analyses at standard marketing stage.

vii. Photographic records.

viii. Environmental and solar radiation measurements.

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 treatment and its interaction with variety and sticking date and the interaction of chemical growth regulators with supplementary lighting.

In addition, the standard deviations of height per plant and maximum bud stage per pot were calculated to assess overall pot uniformity relative to treatment. (The more uniform the pot the smaller the standard deviation).

The influence of marketing stage on bud development and deterioration in shelf life was also examined in a combined score for records of bud stage and bud deterioration.

Probability rates P = $P<0.05$, $P<0.01$, $P<0.001$

N.S. Non significant

L.S.D. Least significant difference (at P = 0.05)

RESULTS

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

Full records of treatment means for each sticking date per variety are presented in Appendix III, page 43. The following highlights key observations from the records collected.

1.1 Effect of supplementary lighting on production time

The following main effects were noted for pots assessed at standard marketing stage (as defined on page 7 above).

a. Influence of L.D. lighting treatment on production time ($P < 0.001$)

Mean number of days from sticking to marketing

Unlit L.D. 5000 lux weeks 1-2 S.D.	5000 lux week 2 L.D. 5000 lux weeks 1-2 S.D.	Unlit L.D. 5000 lux weeks 1-3 S.D.
69.7	70.3	70.6

L.S.D. (P = 0.05) = 0.6

A total of three weeks supplementary lighting supplied as 5000 lux in the second week of long days and the first two weeks short days increased production time in comparison with the 5000 lux treatments applied over the short day period only.

b. Influence of S.D. lighting treatment on production time ($P < 0.001$)

Mean number of days from sticking to marketing

Unlit throughout S.D.	2000 lux throughout S.D.	5000 lux weeks 1-3 S.D.	5000 lux weeks 1-2 S.D.
72.6	70.6	68.5	69.7

L.S.D. (P = 0.05) = 0.6

Supplementary lighting during S.D. significantly reduced production time. 5000 lux for the first three weeks of S.D. was the most effective treatment reducing production time by an average of 4.1 days overall.

c. Influence of variety on production time

Mean number of days from sticking to marketing

Decorative varieties			Single varieties		
Charm	Dark Yellow Boaldi	Yuba	Davis	Miramar	Tan
70.8	71.5	73.0	69.9	71.2	65.6

L.S.D (P = 0.05) = 0.7

Varietal differences in production time of up to 7.4 days were recorded and the fastest times overall were achieved with Tan and Davis. In addition production time for the single varieties collectively at 68.9 days was significantly shorter ($P < 0.001$) than for the individual decorative varieties (i.e. with differences between 1.9 and 4.1 days depending on variety).

d. Influence of sticking date on production time ($P < 0.001$)

Mean number of days from sticking to marketing

Week 41	Week 45	Week 49
68.7	69.7	72.7

L.S.D (P 0.05) = 0.5

Production time was significantly delayed by later sticking dates (ie. as light levels declined).

The following main factor *interactions* were noted:

e. **Influence of sticking date x S.D. lighting on production time (P < 0.001)**

Mean number of days from sticking to marketing

	Unlit throughout S.D.	2000 lux throughout S.D.	5000 lux weeks 1-3 S.D.	5000 lux weeks 1-2 S.D.
Week 41	68.9	68.8	67.8	68.2
Week 45	72.4	69.9	67.8	68.8
Week 49	76.6	73.0	70.0	72.0

L.S.D. (P = 0.05) = 1.1

The delay in total production time caused by sticking in weeks 45 and 49 compared with week 41 was significantly reduced when supplementary lighting was used. Supplementary lighting at 5000 lux during the first three weeks of S.D. was the most effective treatment in this respect.

f. **Influence of sticking date x variety on production time (P < 0.001)**

Mean number of days from sticking to marketing

	Decorative varieties			Single varieties		
	Charm	Dark Yellow Boaldi	Yuba	Davis	Miramar	Tan
Week 41	68.4	68.6	72.3	68.7	69.5	64.5
Week 45	70.1	71.4	72.0	69.5	71.0	64.1
Week 49	74.0	74.5	74.7	71.4	73.1	68.2

L.S.D (P = 0.05) = 1.2

Delays in production time due to later sticking dates varied significantly with variety. Dark Yellow Boaldi and Charm, for example, were the most susceptible to these delays with increases in production time of up to 5.9 days and 5.6 days respectively. In comparison, a delay of up to 2.4 days resulted from the later sticking dates with Yuba.

g. Influence of sticking date x L.D. lighting treatment x variety on production time

Mean number of days from sticking to marketing

	Decorative varieties			Single varieties		
	Charm	Dark Yellow Boaldi	Yuba	Davis	Miramar	Tan
Unlit L.D. (5000 lux weeks 1-2 S.D.)						
Week 41	67.7	68.2	71.0	68.3	69.4	64.6
Week 45	69.7	69.9	70.9	68.9	70.2	63.4
Week 49	73.5	72.8	74.5	71.4	71.6	68.0
5000 lux week 2 L.D. (5000 lux weeks 1-2 S.D.)						
Week 41	69.0	68.4	74.9	70.6	69.9	65.3
Week 45	69.7	71.7	71.4	68.8	71.6	63.5
Week 49	72.2	71.6	75.1	69.2	74.6	67.7
Unlit L.D. (5000 lux weeks 1-3 S.D.)						
Week 41	67.8	67.9	70.8	66.7	69.2	64.1
Week 45	68.0	69.6	69.3	67.6	69.0	63.1
Week 49	71.0	72.0	71.5	68.8	71.3	65.6

Note: The above individual treatment means could not be tested for statistical significance because replication in the trial was based on sticking week.

Production time of plants receiving supplementary lighting during long days was slightly longer or comparable to that of plants receiving no L.D. lighting but equivalent S.D. lighting treatments.

There were no other significant main effects or factor interactions on production time due to L.D. supplementary lighting treatment.

h. Influence of sticking date x S.D. lighting treatment x variety on production time

Mean number of days from sticking to marketing

	Decorative varieties			Single varieties		
	Charm	Dark Yellow Boaldi	Yuba	Davis	Miramar	Tan
Unlit throughout S.D.						
Week 41	68.5	69.3	71.8	69.9	69.5	64.2
Week 45	72.4	74.3	74.6	72.0	73.9	67.3
Week 49	78.1	79.9	78.3	75.0	76.6	71.7
2000 lux throughout S.D.						
Week 41	68.9	69.0	73.0	68.0	69.6	64.4
Week 45	70.8	71.3	73.6	70.1	70.2	63.3
Week 49	75.3	76.2	74.0	72.8	71.6	68.0
5000 lux weeks 1-3 of S.D.						
Week 41	67.8	67.9	70.8	66.7	69.2	64.1
Week 45	68.0	69.6	69.3	67.6	69.0	63.1
Week 49	71.0	72.0	71.5	68.8	71.3	65.6
5000 lux weeks 1-2 of S.D.						
Week 41	67.7	68.2	71.0	68.3	69.4	64.6
Week 45	69.7	69.9	70.9	68.9	70.2	63.4
Week 49	73.5	72.8	74.5	71.4	71.6	68.0

Note: The above individual treatment means could not be tested for statistical significance because replication in the trial was based on sticking week.

Under the poorer natural light conditions of the later sticking weeks, supplementary lighting during S.D. advanced flowering. Supplementary lighting with 5000 lux for the first three weeks of S.D. had the greatest influence over production time with a decrease of up to 7.9 days for Dark Yellow Boaldi stuck in week 49.

1.2 Effect of supplementary lighting on plant height

The following main effects were noted for pots assessed at standard marketing stage:

a. Influence of L.D. lighting treatment on plant height ($P < 0.001$)

Mean plant height (cm)

Unlit L.D. 5000 lux weeks 1-2 S.D.	5000 lux week 2 L.D. 5000 lux weeks 1-2 S.D.	Unlit L.D. 5000 lux weeks 1-3 S.D.
17.2	18.9	17.3

L.S.D. (P = 0.05) = 0.4

Plant height was significantly increased by supplementary lighting during the second week of L.D. There was no comparable increase in height for the treatment receiving the same quantity of light in the short day period only.

b. Influence of S.D. lighting treatment on plant height ($P < 0.001$)

Mean plant height (cm)

Unlit throughout S.D.	2000 lux throughout S.D.	5000 lux Weeks 1-3 S.D.	5000 lux Weeks 1-2 S.D.
16.2	15.7	17.3	17.2

L.S.D. (P = 0.05) = 0.4

The 5000 lux treatments during S.D. significantly increased plant height while 2000 lux throughout S.D. reduced plant height.

c. **Influence of variety on plant height ($P < 0.001$)**

Mean plant height (cm)

Decorative varieties			Single varieties		
Charm	**Dark Yellow Boaldi**	**Yuba**	**Davis**	**Miramar**	**Tan**
15.0	16.6	18.7	18.0	17.0	17.0

L.S.D. (P = 0.05) = 0.5

Variety had a significant influence on plant height with Charm being the most compact variety and Yuba the tallest.

d. **Influence of sticking date on plant height ($P < 0.001$)**

Mean plant height (cm)

Week 41	**Week 45**	**Week 49**
17.6	16.6	17.0

L.S.D. (P = 0.05) = 0.3

Plant height decreased significantly as light conditions deteriorated. Sticking in week 45 produced the shortest plants overall.

The following main factor *interactions* were noted.

e. Influence of sticking date x L.D. lighting on plant height (P = 0.004)

Mean plant height (cm)

	Unlit L.D. 5000 lux weeks 1-2 S.D.	5000 lux week 2 L.D. 5000 lux week 1-2 S.D.	Unlit L.D. 5000 lux weeks 1-3 S.D.
Week 41	17.5	18.9	17.7
Week 45	16.8	18.4	17.1
Week 49	17.3	19.4	17.1

L.S.D. (P = 0.05) = 0.7

The increase in plant height associated with supplementary lighting during L.D. was greater in the poorer natural light conditions of later sticking dates.

f. Influence of sticking date x S.D. lighting on plant height (P = 0.004)

Mean plant height (cm)

	Unlit throughout S.D.	2000 lux throughout S.D.	5000 lux weeks 1-3 S.D.	5000 lux weeks 1-2 S.D.
Week 41	17.4	16.5	17.7	17.5
Week 45	15.2	15.4	17.1	16.8
Week 49	16.1	15.1	17.1	17.3

L.S.D. (P = 0.05) = 0.7

The increase in plant height linked to 5000 lux supplementary lighting for the first three weeks of S.D. (noted above) was more pronounced as natural light conditions deteriorated. The height reduction linked with supplementary lighting at 2000 lux throughout S.D. was most effective for plots stuck in weeks 41 and 49, while there was no significant difference in this respect for plants stuck in week 45.

g. Influence of variety x sticking date on plant height ($P < 0.001$)

Mean plant height (cm)

	Decorative varieties			Single varieties		
	Charm	Dark Yellow Boaldi	Yuba	Davis	Miramar	Tan
Week 41	14.0	17.8	19.1	19.6	16.5	18.5
Week 45	14.8	16.0	17.7	17.3	16.6	17.0
Week 49	16.2	16.0	19.4	17.0	17.9	15.6

L.S.D. (P = 0.05) = 0.8

Response of plant height to the poorer natural light conditions of later sticking dates varied with variety. Charm and Miramar for example were taller when stuck in weeks 45 and 49 compared with week 41, whereas Dark Yellow Boaldi, Davis and Tan were more compact when stuck in weeks 45 and 49.

The following effects of supplementary lighting on the variability of plant heights, expressed as the log of variance per plant from average height (where a larger figure indicates greater variability) were noted.

h. Influence of L.D. lighting treatment on variability of plant height (N.S.)

Mean log of variance from average height per pot

Unlit L.D. 5000 lux weeks 1-2 S.D.	5000 lux week 2 L.D. 5000 lux weeks 1-2 S.D.	Unlit L.D. 5000 lux weeks 1-3 S.D.
0.17	0.24	0.13

L.S.D. (P = 0.05) = 0.10

i. Influence of S.D. lighting treatment on variability of plant height (N.S.)

Mean log of variance from average height per pot

Unlit throughout S.D.	2000 lux throughout S.D.	5000 lux weeks 1-3 S.D.	5000 lux weeks 1-2 S.D.
0.16	0.08	0.13	0.17

L.S.D. (P = 0.05) = 0.10

None of the supplementary lighting treatments significantly influenced variability in plant height. General trends do however indicate greater uniformity using 2000 lux supplementary lighting throughout S.D. and poorer uniformity using supplementary lighting during the L.D. period.

j. Influence of sticking date on variability of plant height (P < 0.001)

Mean log of variance from average height per pot

Week 41	Week 45	Week 49
0.17	0.26	0.03

L.S.D. (P = 0.05) = 0.07

Pots stuck during week 45 were the most variable whilst those stuck during week 49 were the most uniform.

k. Influence of variety on variability in plant height (P = 0.05)

Mean log of variance from average height pot pot

Decorative varieties			Single varieties		
Charm	Dark Yellow Boaldi	Yuba	Davis	Miramar	Tan
0.07	0.16	0.19	0.18	0.05	0.28

L.S.D. (P = 0.05) = 0.10

Miramar and Charm were the most uniform in terms of plant height of the varieties tested.

1.3 Effect of supplementary lighting on pot maximum and minimum spread

Supplementary lighting treatments had no significant influence on maximum and minimum pot spread, however, the following main effects were noted for pots assessed at standard marketing stage.

a. Influence of sticking date on maximum and minimum pot spread (P < 0.001)

Mean maximum and minimum spread (cm)

	Week 41	Week 45	Week 49
Max	33.6	32.7	31.1
Min	30.0	29.4	28.5

L.S.D. (P = 0.05) = 0.6 - maximum spread
0.7 - minimum spread

Later sticking dates significantly reduced both the maximum and minimum pot spread.

b. Influence of variety on maximum and minimum pot spread

Mean maximum and minimum spread (cm)

	Decorative varieties			Single varieties		
	Charm	Dark Yellow Boaldi	Yuba	Davis	Miramar	Tan
Max.	32.0	34.4	31.6	33.7	31.9	31.0
Min.	29.3	30.9	28.6	30.4	28.8	27.9

L.S.D. (P = 0.05) = 0.8 - maximum spread
= 1.0 - minimum spread

Varietal differences in pot spread were recorded and Tan was the most compact, in terms of spread, of the varieties assessed.

1.4 Effect of supplementary lighting on flower development

1.4.1 Bud expansion - Number of buds at stages 3 and 4 per pot

The following main effects were noted for pots assessed at standard marketing stage.

a. Influence of L.D. supplementary lighting on bud expansion (P = 0.002)

Mean number of buds at stages 3 and 4 per pot

Unlit L.D. 5000 lux weeks 1-2 S.D.	5000 lux week 2 L.D. 5000 lux weeks 1-2 S.D.	Unlit L.D. 5000 lux weeks 1-3 S.D.
16.9	18.4	16.1

L.S.D. (P = 0.05) = 2.0

There was no significant difference between plants receiving 5000 lux for the first two weeks of short days and those receiving the same short day treatment with an additional week in long days at 5000 lux. However, when 5000 lux treatments over a three week total period were compared, significantly higher numbers of buds at stages 3 and 4 were produced by commencing the lighting treatment from the second week of long days rather than from the start of short days.

b. Influence of S.D. supplementary lighting on bud expansion (P = 0.002)

Mean number of buds at stages 3 and 4 per pot

Unlit throughout S.D.	2000 lux throughout S.D.	5000 lux weeks 1-3 S.D.	5000 lux weeks 1-2 S.D.
18.2	20.3	16.1	16.9

L.S.D. (P = 0.05) = 2.0

Flower expansion was significantly increased by 2000 lux supplementary lighting throughout S.D. with an increase of two buds per pot overall compared with plants receiving no supplementary lighting. A slight decrease in buds at stages 3 and 4 was also recorded for both 5000 lux supplementary lighting treatments.

c. Influence of sticking date on bud expansion (P < 0.001)

Mean number of buds at stages 3 and 4 per pot

Week 41	Week 45	Week 49
21.1	13.7	19.2

L.S.D. (P = 0.05) = 1.5

Flower expansion significantly decreased as natural light conditions deteriorated. Overall, pots stuck in week 45 had the lowest mean number of buds at stages 3 and 4.

d. Influence of variety on bud expansion

Mean number of buds at stages 3 and 4 per pot

Decorative varieties			Single varieties		
Charm	Dark Yellow Boaldi	Yuba	Davis	Miramar	Tan
10.3	23.4	20.4	24.6	15.4	13.7

L.S.D. (P = 0.05) = 2.2

Davis and Dark Yellow Boaldi produced the greatest number of buds at stages 3 and 4 while Charm produced the lowest mean number of buds at stages 3 and 4.

1.4.2. Total number of buds and flowers per pot

The following main effects were noted for pots assessed at standard marketing stage:

e. **Influence of S.D. supplementary lighting on total number of flowers produced (P < 0.001)**

Mean total number of buds and flowers

Unlit throughout S.D.	2000 lux throughout S.D.	5000 lux weeks 1-3 S.D.	5000 lux weeks 1-2 S.D.
41.8	50.4	37.4	39.7

L.S.D. (P = 0.05) = 2.6

Supplementary lighting at 2000 lux throughout S.D. produced significantly more buds and flowers than no supplementary lighting with an increase of 8.6 buds per pot overall. In contrast, total number of buds and flowers was significantly decreased by both 5000 lux supplementary lighting treatments.

f. **Influence of sticking date on total number of flowers produced (P < 0.001)**

Mean total number of buds and flowers

Week 41	Week 45	Week 49
49.5	32.5	43.7

L.S.D. (P = 0.05) = 2.0

The later sticking dates significantly reduced the total number of buds and flowers produced with, for example, an average of 16 fewer buds and flowers on pots stuck in week 45 compared with week 41.

g. Influence of variety on total number of flowers produced

Mean total number of buds and flowers

Decorative varieties			Single varieties		
Charm	Dark Yellow Boaldi	Yuba	Davis	Miramar	Tan
37.3	43.2	39.8	52.4	35.2	41.4

L.S.D. (P = 0.05) = 2.2

Variety influenced the total number of buds and flowers produced. Davis produced the highest number of buds and flowers and Miramar produced the lowest number.

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

The average maximum bud stage per plant at marketing was stage 5. Supplementary lighting had no significant influence on the uniformity of flowering (assessed as the standard deviation of maximum bud stage per plant from the average maximum bud stage per pot).

The main effects on uniformity of flowering were as follows:

h. Influence of sticking date on uniformity of flowering (P < 0.001)

Mean standard deviation of maximum bud stage

Week 41	Week 45	Week 49
0.92	1.20	1.07

L.S.D. (P = 0.05) = 0.10

Pot uniformity was significantly decreased by the later sticking dates.

i Influence of variety on uniformity of flowering

Mean standard deviation of maximum bud stage

Decorative varieties			Single varieties		
Charm	Dark Yellow Boaldi	Yuba	Davis	Miramar	Tan
1.06	0.99	1.22	1.16	0.86	1.09

L.S.D. (P = 0.05) = 0.14

Miramar was the most uniform variety for flowering while Yuba was the least uniform.

2. Assessment of the stage of marketing and its potential interaction with supplementary lighting on shelf life

Since an open flower has a greater impact on visual pleasure than a closed bud, records were assigned weightings, chosen in consultation with growers, and combined into scores indicating extent of visual pleasure.

Full records of scores for each sticking date per variety are presented in Appendix IV, page 54. The following highlights key observations from records collected.

2.1 Effect of supplementary lighting and stage of marketing on bud deterioration during shelf life

For statistical analyses, records of numbers of buds at deterioration stages D1-D3 were weighted according to their relative impact on overall visual quality of the pot. Hence buds with only partial deterioration (stage D1) were assigned a weighting of 7; buds with moderate deterioration (stage D2) were assigned a weighting of 4 and severely deteriorated buds (stage D3) were weighted at 1. These figures were combined into a score for deterioration of buds per pot as follows:

Bud deterioration score = 7 x number of buds at stage D1
+ 4 x number of buds at stage D2
+ 1 x number of buds at stage D3

The highest scores therefore indicate the lowest levels of bud deterioration and therefore greatest level of visual pleasure. As deterioration increases, visual pleasure from the pot will decrease which will be reflected by a lower score.

Supplementary lighting treatments had no significant influence on bud deterioration score for the three marketing stages assessed. The following main effects on bud deterioration were recorded.

a. Influence of marketing stage on bud deterioration ($P < 0.001$)

Mean bud deterioration score = (7 x nD1) + (4 x nD2) + (nD3)

Stage 1	Stage 2	Stage 3
76.5	89.1	116.0

L.S.D. ($P = 0.05$) = 7.1

Stage of marketing had a significant influence over bud deterioration during the shelf life period. Pots marketed at stage 3 had significantly lower levels of bud deterioration than those marketed at earlier stages of development.

b. Influence of variety on bud deterioration ($P < 0.001$)

Mean bud deterioration score = (7 x nD1) + (4 x nD2) + nD3)

Decorative varieties		Single varieties	
Charm	Dark Yellow Boaldi	Davis	Miramar
57.2	117.5	134.5	66.3

L.S.D. ($P = 0.05$) = 0.2

Variety had a significant influence over bud deterioration. Overall, bud deterioration during the shelf life period was most extensive for the variety Charm, whilst Davis had the lowest level of bud deterioration.

The following main factor *interactions* were noted.

c. Influence of marketing stage x variety on bud deterioration

Mean bud deterioration score = (7 x nD1) + (4 x nD2) + (nD3)

	Decorative varieties		Single varieties	
	Charm	Dark Yellow Boaldi	Davis	Miramar
Stage 1	48.5	98.5	108.7	50.4
Stage 2	59.5	110.6	122.7	63.7
Stage 3	63.6	143.4	172.0	84.7

L.S.D. (P = 0.05) = 12.4

The lowest level of bud deterioration in shelf life for all varieties was recorded from pots at marketing stage 3 as noted in 'a' above. Variation in levels of deterioration with marketing stage was influenced by variety, however, with marketing stage having the greatest impact on bud deterioration of Davis.

d. Influence of marketing stage x length of time in shelf life on bud deterioration (P < 0.001)

Mean bud deterioration score = (7 x nD1) + (4 x nD2) + (nD3)

	Week 3 of shelf life	Week 4 of shelf life	Week 5 of shelf life
Stage 1	61.9	99.3	68.4
Stage 2	92.7	108.6	66.1
Stage 3	152.4	120.7	74.7

L.S.D. (P = 0.05) = 10.9

Note: Bud deterioration was first recorded in week 3 of shelf life and hence there were no scores for earlier weeks in shelf life. Increases in scores for week 4 of shelf life were attributed to dead buds recorded in week 3 falling off plants before the next assessment.

At the onset of bud deterioration, there were significant differences between pots selected at different marketing stages, with the greatest levels of deterioration associated with the earlier marketing stages. As length of time in shelf life continued, however, the influence of marketing stage on bud deterioration was less marked until after 5 weeks in shelf life there were no significant differences.

2.2 Effect of supplementary lighting and stage of marketing on bud expansion during shelf life

For statistical analyses, records of number of buds at stages 1&2, 3&4 and 5+ were weighted according to their relative impact on visual quality of the pot and combined into an overall score for bud expansion. Hence buds with very little expansion (stages 1 and 2) were assigned a weighting of 1, moderate bud expansion (stages 3 and 4) was assigned a weighting of 4; and buds at stage 5 to maximum bud expansion were assigned a weighting of 7. The score for bud expansion was calculated by adding together the weighted figures of number of buds at each stage and dividing by total number of buds to give an average score as follows:

Bud opening score =

$$\frac{1 \times \text{no.buds at stages 1\&2} + 4 \times \text{no. buds at stages 3\&4} + 7 \times \text{no. buds at stage 5+}}{\text{no.buds at stages 1\&2} + \text{no. buds at stages 3\&4} + \text{no buds at stage 5+}}$$

High scores therefore indicate the greatest visual pleasure due to large numbers of open buds. Less well developed buds on a pot will give less usual pleasure which will be reflected by a low score.

The following main effects were noted:

a. Influence of marketing stage on bud opening during shelf life ($P < 0.001$)

Mean bud opening score = $\frac{(\text{nB1\&2}) + (4 \times \text{nB3\&4}) + (7 \times \text{nB5+})}{(\text{nB1\&2}) + (\text{n B3\&4}) + (\text{nB5+})}$

Stage 1	Stage 2	Stage 3
3.45	3.79	4.42

L.S.D. (P = 0.05) = 0.12

Marketing stage had a significant influence on bud expansion with pots selected at stage 3 giving the greatest visual pleasure during the shelf life period.

b. Influence of variety on bud opening during shelf life

$$\text{Mean bud opening score} = \frac{(nB1\&2) + (4 \times nB3\&4) + (7 \times nB5+)}{(nB1\&2) + (n\ B3\&4) + (nB5+)}$$

Decorative varieties		Single varieties	
Charm	**Dark Yellow Boaldi**	**Davis**	**Miramar**
3.11	4.11	4.09	4.24

L.S.D. (P = 0.05) = 0.19

Over the length of the shelf life period, Charm had the lowest bud opening score. There were no significant differences separating the other varieties assessed.

The following main factor *interactions* were noted.

c. Influence of marketing stage x sticking date on bud opening during shelf life

$$\text{Mean bud opening score} = \frac{(nB1\&2 + (4 \times nB3\&4) + (7 \times nB5+)}{(nB1\&2) + (nB3\&4) + (nB5+)}$$

	Stage 1	**Stage 2**	**Stage 3**
Week 41	3.29	3.45	3.45
Week 45	4.01	4.34	5.18
Week 49	3.04	3.58	4.64

L.S.D. (P = 0.05) = 0.21

The influence of marketing stage on bud development during shelf life was greater under the poorer light conditions of later sticking dates.

d. Influence of marketing stage x length of time in shelf life on bud opening ($P < 0.001$)

$$\text{Mean bud opening score} = \frac{(nB1\&2) + (4 \times nB3\&4) + (7 \times nB5+)}{(nB1\&2) + (n\ B3\&4) + (nB5+)}$$

	Week 1 of shelf life	Week 2 of shelf life	Week 3 of shelf life	Week 4 of shelf life
Stage 1	3.36	4.07	3.53	2.83
Stage 2	4.07	4.48	3.48	3.14
Stage 3	5.35	4.98	3.90	3.46

L.S.D. (P = 0.05) = 0.24

The influence of marketing stage on bud expansion during the shelf life period varied significantly with time. An initial increase in bud opening score by the second week of shelf life followed by a gradual decline was recorded for pots selected at marketing stages 1 and 2. In comparison, bud opening score for pots selected at marketing stage 3 declined over the whole shelf life period. The greatest bud opening scores (and hence visual pleasure) were, however, consistently linked to pots selected at marketing stage 3 throughout shelf life.

3. Observation trial - Combined influence of supplementary lighting and growth regulants on production time and plant form.

Full records of treatment means for each sticking date per variety are presented in Appendix V, page 61. The following highlights key observations of the records collected.

3.1 Effect of 2000 lux S.D. supplementary lighting and its interaction with growth regulants on production time.

a. Influence of 2000 lux S.D. supplementary lighting x alar on production time of Yuba (N.S.)

Mean number of days from sticking to marketing

	Unlit throughout S.D.	2000 lux throughout S.D.
+ Alar	75.4	71.8
- Alar	74.9	72.8

L.S.D. (P = 0.05) = 2.6

b. Influence of 2000 lux S.D. supplementary lighting x phosphon on production time of Charm (N.S.)

Mean number of days from sticking to marketing

	Unlit throughout S.D.	2000 lux throughout S.D.
+ Phosphon	73.0	70.3
- Phosphon	72.1	68.7

L.S.D. (P = 0.05) = 2.6

There was no significant interaction either between the use of alar and supplementary lighting on production time of Yuba or between the use of phosphon and supplementary lighting on production time of Charm.

3.2 Effect of 2000 lux S.D. supplementary lighting and its interaction with growth regulants on plant height

a. Influence of 2000 lux S.D. supplementary lighting on plant height (N.S.)

Mean plant height (cm)

Unlit throughout S.D.	2000 lux throughout S.D.
16.9	16.4

L.S.D. (P = 0.05) = 1.6

Although a reduction in height was associated with the 2000 lux supplementary treatment (as was also noted in the main trial), this effect was found not to be significant for the varieties Yuba and Charm collectively.

b. Influence of 2000 lux S.D. supplementary lighting x alar on height of Yuba ($P < 0.001$)

Mean plant height (cm)

	Unlit throughout S.D.	2000 lux throughout S.D.
+ Alar	16.9	16.4
- Alar	19.9	19.6

L.S.D. (P = 0.05) = 1.9

c. Influence of 2000 lux S.D. supplementary lighting x phosphon on height of Charm (N.S.)

Mean plant height (cm)

	Unlit throughout S.D.	2000 lux throughout S.D.
+ Phosphon	14.2	13.6
- Phosphon	16.0	15.5

L.S.D. (P = 0.05) = 1.9

Alar and phosphon reduced the height of Yuba and Charm respectively. In addition, there was a significant interaction between alar and supplementary lighting on Yuba with the reduction in plant height increasing under supplementary lighting. There was no significant interaction between phosphon and supplementary lighting on the height of Charm.

3.3 Effect of 2000 lux S.D. supplementary lighting and its interaction with growth regulants on mean pot spread

a. Influence of 2000 lux S.D. supplementary lighting x alar on mean pot spread of Yuba (NS).

Mean pot spread (cm)

	Unlit throughout S.D.	2000 lux throughout S.D.
+ Alar	30.1	28.8
- Alar	30.7	30.7

L.S.D. (P = 0.05) = 2.0

b. Influence of 2000 lux S.D. supplementary lighting x phosphon on mean pot spread of Charm (N.S.)

Mean pot spread (cm)

	Unlit throughout S.D.	2000 lux throughout S.D.
+ Phosphon	28.6	30.3
- Phosphon	30.1	31.0

L.S.D. (P = 0.05) = 2.0

There was no significant interaction either between the use of alar and supplementary lighting on pot spread of Yuba or between the use of phosphon and supplementary lighting on pot spread of Charm.

3.4. Effect of 2000 lux S.D. supplementary lighting and its interaction with growth regulants on flower development

a. **Influence of 2000 lux S.D. supplementary lighting x alar on bud expansion of Yuba (N.S.)**

Mean number of buds at stages 3 and 4 per pot

	Unlit throughout S.D.	2000 lux throughout S.D.
+ Alar	19.3	26.7
- Alar	18.4	26.2

L.S.D. (P = 0.05) = 3.7

b. **Influence of 2000 lux S.D. supplementary lighting x phosphon on bud expansion of Charm (N.S.)**

Mean number of buds at stages 3 and 4 per pot

	Unlit throughout S.D.	2000 lux throughout S.D.
+ Phosphon	10.5	11.0
- Phosphon	10.0	11.4

L.S.D. (P = 0.05) = 3.7

Bud expansion was greater under 2000 lux S.D. supplementary lighting as noted in 1.4 above, but there was no significant interaction between alar and lighting on Yuba or phosphon and lighting on Charm.

4. Compost and leaf analyses at marketing

Full records of compost and leaf analyses for each sticking date per variety are presented in Appendix VI (page 66) and Appendix VII (Page 88) respectively.

There were no apparent consistent trends in the nutrient levels of the growing media relative to supplementary lighting treatment, marketing stage or growth regulator treatment. A slight increase in residual nutrients and corresponding drop in pH in the growing media was apparently linked with the two later sticking dates which also had longer production times and consequently more liquid feed applications.

Overall residual nutrient levels in the growing media at the end of the crop and following shelf life were within the low levels expected for the stage of the crop.

There was also apparently no consistent treatment effects on the levels of nutrients in foliage samples. Dry matter was slightly lower in the unlit treatment for the varieties Dark Yellow Boaldi, Yuba, Davis, Miramar and Tan but with Charm the unlit treatment was actually linked with the highest dry matter content.

Overall, there are no indications of nutrient deficiencies in any of the foliage samples analysed and major nutrients were generally at levels corresponding to the ranges recommended by ADAS. Magnesium and manganese levels, however, were consistently higher than these recommended levels.

5. Photographic records

(Appendix IX, page 99)

6. Solar radiation

Details of solar radiation during the trial are shown in Appendix X, page 108.

DISCUSSION

Supplementary lighting treatments during short days were clearly beneficial in reducing the production time of a range of both double and single American bred varieties. In accordance with previous studies on four double American varieties (Finlay, 1992), the most effective treatment was lighting at 5000 lux for the first three weeks of short days which overall, reduced production time by 4 days. Production time of the single varieties was shorter than for the double varieties, but all varieties had the same response to the treatments applied. The actual reduction in production time did vary with variety and, for example, the most effective treatment reduced the production time of Dark Yellow Boaldi by 7.9 days for sticking in week 49 and by 5.3 days for Miramar. Significant reductions in production time were also achieved with the other short day supplementary lighting treatments assessed.

There were no benefits in production time from the 5000 lux treatment applied for the second week of long days in combination with the first two weeks of short days as indicated by observations made in previous studies (Finlay, 1992). In contrast with this earlier work, there were no significant differences in total buds or uniformity of flowering associated with the long day lighting treatment although a slight increase in the number of buds at stages 3 and 4 was recorded. It should be noted, however, that in the current study lighting in long days was applied in combination with only one of the short day lighting treatments (5000 lux for the first two weeks of short days) whereas all treatments (including no short day supplementary lighting) were combined with and without long day supplementary lighting in the 1991/92 work.

Sticking date, and hence natural light conditions influenced response to supplementary lighting and, as expected, delays in production time due to poorer natural light experienced with later sticking were reduced using supplementary lighting. Since the 5000 lux treatments were more effective in reducing production time than the 2000 lux treatment, despite the fact that the crop spends the greater proportion of short days in natural light, it would appear that the bud initiation phase of growth is influenced by the high intensity lighting treatment, resulting in the faster production times observed (as observed by Cockshull & Hughes, 1972).

Taller plants resulted from the 5000 lux treatments applied during both long days and short days, again reflecting previous studies (Finlay, 1992), although an increase in variability of height was not noted in the current trial. The increase in height associated with the 5000 lux treatments was also greater under poorer natural light conditions. Conversely, 2000 lux supplementary lighting throughout S.D. reduced plant height and appeared to reduce variability in height (although this effect was not statistically significant).

Further benefits of the 2000 lux treatment were noted in terms of quality and flowering and hence visual pleasure. This treatment increased both the total production of buds and flowers and the number of flowers opening (i.e. at bud stages 3 and 4) at marketing. Plants were also

more compact with darker foliage under this treatment. In contrast the 5000 lux treatment slightly reduced both total bud production and the number of open flowers.

None of the supplementary lighting treatments influenced the shelf life performance of the varieties assessed. Marketing stage, however, had a significant influence over both the development and deterioration (and hence visual pleasure) of flowers during shelf life.

Bud deterioration (including distortion of buds on opening) was lower overall for pots marketed at stage 3 than at stages 1 and 2 and in particular a high rate of bud death was associated with the earlier marketing stages.

Since pots marketed at stage 3 were the most advanced at point of sale, it may have been expected that they would have the highest levels of deterioration by the end of shelf life but in fact no significant differences between marketing stages were recorded. In addition, the impact of deterioration on the visual pleasure of the pots by the middle of the shelf life period (i.e. week 3) was greater for marketing stages 1 and 2 than for stage 3. The apparent decrease in deterioration in week 4 of shelf life compared with week 3 for marketing stages 1 and 2 was apparently due to dead buds falling off plants and hence not being recorded in the week 4 figures.

Due to the differences in marketing stage at the beginning of shelf life, stage 3 pots had more open flowers than stages 1 and 2. The bud opening score indicates that the stage 3 pots also continued to have more open flowers throughout the shelf life period. The influence of marketing stage on the number of open flowers in shelf life was clearly linked to natural light conditions with marketing stage 3 giving the main advantage, in terms of open flowers, for pots stuck in weeks 45 and 49. Comparison of flower opening during shelf life indicates that there was more development of flowers from the earlier marketing stages, but the greatest visual pleasure from open flowers was associated with marketing stage 3 throughout shelf life.

Results of the observation trial indicate that the reduction in height of plants treated with alar is further enhanced under 2000 lux supplementary lighting throughout short days. There was, however, no similar interaction between the use of Phosphon and 2000 lux supplementary lighting. It is possible therefore that the height reduction observed in the main trial with the 2000 lux treatment was due, at least in part, to this apparent increased efficiency of alar.

CONCLUSIONS

This study successfully illustrated that the benefits of supplementary lighting previously demonstrated with four decorative American bred varieties may also be applied to a range of single varieties.

- Supplementary lighting at 5000 lux for the first three weeks of short days was the most effective treatment in terms of reducing production time.

- Compared with the unlit treatment, plants were more compact when grown under 2000 lux supplementary lighting throughout short days and were taller when grown under all of the 5000 lux treatments.

- Supplementary lighting at 2000 lux throughout short days also increased flower initiation and development.

- Supplementary lighting at 5000 lux for the second week of long days combined with the first two weeks of short days does not yield any significant benefits to the crop in terms of production time or total number of buds and flowers compared with lighting at 5000 lux for the first two weeks of long days only.

The relative advantages of the treatments assessed would therefore need to be considered against the varieties grown, resources available, and the type of pot required by each marketing outlet.

The economic evaluation of the treatments completed in previous studies (Finlay, 1992) and repeated in Appendix VIII, page 97 would apply to the successful short day treatments in the current trial (although capital costs and electricity charges will of course vary with time).

The importance of marketing stage on the winter grown crop was also clearly demonstrated in this study.

- Pots selected at marketing stage 3 gave greater visual pleasure due to the number of open flowers at point of sale and continued to perform well compared with earlier marketing stages throughout the shelf life period.

- Supplementary lighting did not significantly affect performance in shelf life.

Observations with growth regulators have also indicated that the efficiency of alar may be improved under 2000 lux supplementary lighting throughout short days and the height reduction with this lighting treatment noted in the main trial may have been a result of this interaction.

RECOMMENDATIONS FOR FURTHER WORK

Improvements in the production of American bred varieties are clearly possible with the use of supplementary lighting but the economic returns must balance out the increasing costs for the ongoing viability of this technique. 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.

In addition the influence of difference in temperature (DIF) as a method of growth regulation has stimulated much interest within the industry. Trials at Littlehampton (Langton, 1993) and Efford (Sach and Hand, 1994) have demonstrated the potential of negative DIF (DROP) treatments as a method of height control. For the winter production of pot 'mums it is important to be able to integrate this technique with that of supplementary lighting.

It is also recognised that supplementary lighting regimes, particularly 2000 lux throughout short days, may influence the frequency of irrigation/nutrition and therefore shelf life of the product.

Hence there is need to:

a) Evaluate the combined effects of supplementary lighting and DIF (DROP) on winter quality of commercially grown pot 'mum varieties

b) Examine the interaction of pot spacing with supplementary lighting and DIF (DROP) regimes and its effects on quality of product and economics of production

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

APPENDIX I

Chemical growth regulation - rates of application

Variety	Phosphon g/l in compost	Week 41 g/l	Week 41 ppm	Alar # Week 45 g/l	Alar # Week 45 ppm	Week 49 g/l	Week 49 ppm
Charm	0.2	2.4+1.5	2000+1250	1.5	1250	0.7	600
Dark Yellow Boaldi	0.2	1.5	1250	0.7	600	0.4	300
Yuba	Nil	1.5	1250	0.7	600	0.4	300
Davis	Nil	1.5	1250	0.7	600	0.4	300
Tan	Nil	1.5	1250	0.7	600	0.4	300

applied when breaks were 2 cm to 2.5 cm long reduced concentrations used for later stick dates.

Chemical growth regulation - dates of application

Variety	Stick Date Week 41 7.10.92	Stick Date Week 45 4.11.92	Stick Date Week 49 2.12.92
Charm	10.11.92 (1st) 20.11.92 (2nd)	6.12.92	11.1.93
Dark Yellow Boaldi	10.11.92	6.12.92	11.1.93
Yuba	10.11.92	6.12.92	14.1.93
Davis	10.11.92	6.12.92	11.1.93
Miramar	10.11.92	6.12.92	11.1.93
Tan	10.11.92	6.12.92	11.1.93

(Note: Phosphon included in compost prior to propagation)

APPENDIX II

Pot spacings (for all varieties)

Period	Pots/m²	Pot Spacing (cm)	Duration
Long days	41	15.62 x 15.62	2 weeks
Short days - intermediate	24	20.3 x 20.3	2 weeks
Short days - final	12.5	28.3 x 28.3	To flower

APPENDIX III

MAIN TRIAL: Influence of Supplementary Lighting on Winter Quality - Tables of Results.

Table 1. **Effect of L.D. and S.D. supplementary lighting treatment on total production time (assessed at standard marketing stage)**

Variety	Number of days from sticking to marketing relative to lighting treatment				
	a	b	c	d	e
Stick date: Week 41					
Charm	68.5	68.9	67.8	69.0	67.7
Dark Yellow Boaldi	69.3	69.0	67.9	68.4	68.2
Yuba	71.8	73.0	70.8	74.9	71.0
Davis	69.9	68.0	66.7	70.6	68.3
Miramar	69.5	69.6	69.2	69.9	69.4
Tan	64.2	64.4	64.1	65.3	64.6
Stick date: Week 45					
Charm	72.4	70.8	68.0	69.7	69.7
Dark Yellow Boaldi	74.3	71.3	69.6	71.7	69.9
Yuba	74.6	73.6	69.3	71.4	70.9
Davis	72.0	70.0	67.6	68.8	68.9
Miramar	73.9	70.2	69.0	71.6	70.2
Tan	67.3	63.3	63.1	63.5	63.4
Stick date: Week 49					
Charm	78.1	75.3	71.0	72.2	73.5
Dark Yellow Boaldi	79.9	76.2	72.0	71.6	72.8
Yuba	78.3	74.0	71.5	75.1	74.5
Davis	75.0	72.8	68.8	69.2	71.4
Miramar	76.6	71.6	71.3	74.6	71.6
Tan	71.7	68.0	65.6	67.7	68.0
Statistical mean	72.6	70.6	68.5	70.3	69.7

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

All figures represent mean values of 10 replicate pots per plot

Table 2. Effect of L.D. and S.D. supplementary lighting treatment on plant height (assessed at standard marketing stage)

Variety	Average plant height (cm) relative to lighting treatment				
	a	b	c	d	e
Stick date: Week 41					
Charm	14.0	11.3	14.5	16.1	14.3
Dark Yellow Boaldi	17.4	17.0	18.2	18.6	17.8
Yuba	18.6	18.8	19.5	19.4	19.4
Davis	19.9	18.5	18.7	21.6	19.5
Miramar	16.3	15.9	16.4	17.8	16.0
Tan	18.3	17.3	18.6	20.0	18.1
Stick date: Week 45					
Charm	13.7	13.4	15.4	16.6	15.1
Dark Yellow Boaldi	14.5	15.3	16.2	17.9	16.1
Yuba	16.7	16.5	18.5	18.9	18.0
Davis	15.6	15.8	17.8	19.7	17.9
Miramar	15.1	16.1	17.4	18.1	16.5
Tan	16.0	15.5	17.2	19.4	17.0
Stick date: Week 49					
Charm	15.1	14.5	15.8	19.3	16.3
Dark Yellow Boaldi	15.3	15.1	16.2	17.4	15.9
Yuba	19.0	16.4	18.7	21.3	21.6
Davis	15.3	14.9	17.9	20.3	16.6
Miramar	16.8	15.4	18.3	20.8	18.3
Tan	14.9	14.4	15.9	17.7	15.0
Statistical mean	16.2	15.7	17.3	18.9	17.2

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

All figures represent mean values of 10 replicate pots per plot

Table 3. Effect of L.D. and S.D. supplementary lighting treatment on variability of plant height, expressed as log of variance per plant from average height (assessed at standard marketing stage)

Variety	Log of variance from average of height per plant relative to lighting treatment				
	a	b	c	d	e
Stick date: Week 41					
Charm	0.17	-0.01	0.23	0.05	0.19
Dark Yellow Boaldi	0.19	0.30	-0.01	0.34	0.01
Yuba	0.06	0.08	0.12	0.14	0.14
Davis	0.16	0.08	0.20	0.12	0.21
Miramar	0.20	0.02	-0.07	0.19	-0.15
Tan	0.38	0.24	0.41	0.62	0.56
Stick date: Week 45					
Charm	0.20	0.05	-0.02	0.42	0.23
Dark Yellow Boaldi	0.22	0.12	0.26	0.38	0.50
Yuba	0.34	0.31	0.60	0.54	0.51
Davis	0.25	0.13	0.06	0.28	0.49
Miramar	0.34	0.13	0.11	0.07	0.20
Tan	-0.10	0.10	0.37	0.47	0.28
Stick date: Week 49					
Charm	0.05	-0.06	-0.20	-0.22	-0.09
Dark Yellow Boaldi	0.10	0.04	0.02	0.11	-0.12
Yuba	0.04	0.01	-0.13	0.11	0.01
Davis	0.19	0.12	0.10	0.39	-0.11
Miramar	-0.12	-0.29	0.03	0.13	-0.01
Tan	0.14	0.03	0.18	0.25	0.25
Statistical mean	0.16	0.08	0.13	0.24	0.17

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

All figures represent mean values of 10 replicate pots per plot

Table 4. Effect of L.D. and S.D. supplementary lighting treatment on maximum and minimum pot spread (assessed at standard marketing stage)

Variety		Average plant spread (cm) relative to lighting treatment				
		a	b	c	d	e
Stick date: Week 41						
Charm	Max.	33.6	32.3	34.2	33.5	33.7
	Min.	29.7	29.2	31.7	31.0	30.6
Dark Yellow Boaldi	Max.	37.0	35.6	36.3	36.2	35.5
	Min.	34.0	31.5	32.3	31.4	30.4
Yuba	Max.	31.5	33.5	31.9	29.0	30.9
	Min.	26.2	31.1	27.9	27.2	27.2
Davis	Max.	36.4	36.9	35.6	33.7	37.0
	Min.	32.9	33.5	32.3	30.0	32.2
Miramar	Max.	34.0	30.2	32.2	33.6	31.5
	Min.	30.8	27.3	28.3	29.7	27.9
Tan	Max.	32.9	31.2	32.0	32.6	32.3
	Min.	29.0	29.2	28.4	30.0	28.3
Stick date: Week 45						
Charm	Max.	31.5	31.4	31.7	32.7	31.8
	Min.	28.6	29.5	29.4	28.9	29.6
Dark Yellow Boaldi	Max.	33.9	33.2	33.2	37.7	34.1
	Min.	29.2	30.1	30.7	33.4	30.5
Yuba	Max.	32.9	32.5	31.9	32.1	32.4
	Min.	30.1	29.7	29.2	28.6	29.1
Davis	Max.	34.5	33.2	33.2	33.3	33.7
	Min.	30.8	28.8	30.4	29.6	30.4
Miramar	Max.	32.1	31.6	32.9	33.5	32.1
	Min.	28.2	28.3	29.3	29.9	29.6
Tan	Max.	30.9	31.3	31.1	34.1	30.6
	Min.	27.3	28.5	28.6	29.6	27.2

Continued....

Table 4 (Condt). **Effect of L.D. and S.D. supplementary lighting treatment on maximum and minimum pot spread (assessed at standard marketing stage)**

Variety		Average plant spread (cm) relative to lighting treatment				
		a	b	c	d	e
Stick date: Week 49						
Charm	Max.	31.1	30.7	26.9	31.8	32.7
	Min.	30.0	27.9	24.5	30.1	28.4
Dark Yellow Boaldi	Max.	33.5	33.4	31.9	33.4	31.7
	Min.	31.4	30.0	29.0	30.6	29.0
Yuba	Max.	32.1	29.9	30.6	30.6	31.9
	Min.	29.8	27.4	27.9	27.6	30.2
Davis	Max.	32.3	32.4	31.7	32.7	29.6
	Min.	29.5	30.2	29.0	29.4	26.5
Miramar	Max.	31.1	30.7	31.1	31.3	30.8
	Min.	29.5	28.1	28.7	28.1	28.9
Tan	Max.	26.9	27.3	30.3	31.1	30.2
	Min.	23.3	25.3	28.4	28.3	27.7
Statistical mean	Max.	32.7	32.1	32.1	32.9	32.4
	Min.	29.5	29.2	29.2	29.6	29.1

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

All figures represent mean values of 10 replicate pots per plot

Table 5. Effect of L.D. and S.D. supplementary lighting treatment on bud development (assessed at standard marketing stage)

Variety	Average number of buds at stages 1 and 2 relative to lighting treatment				
	a	b	c	d	e
Stick date: Week 41					
Charm	21.6	28.4	19.5	26.2	21.3
Dark Yellow Boaldi	15.8	18.8	8.9	12.5	11.4
Yuba	14.7	8.3	13.2	9.4	16.0
Davis	18.9	30.2	21.3	13.5	18.1
Miramar	11.1	10.3	7.4	12.0	11.3
Tan	33.4	41.4	26.7	18.7	35.6
Stick date: Week 45					
Charm	15.3	24.6	12.6	12.3	12.3
Dark Yellow Boaldi	6.3	16.4	4.9	4.6	2.2
Yuba	12.0	14.0	9.6	8.0	7.6
Davis	17.9	18.3	14.0	12.5	13.7
Miramar	13.5	16.6	7.6	11.9	12.1
Tan	9.7	31.5	19.2	19.1	15.7
Stick date: Week 49					
Charm	24.0	34.4	16.4	14.5	21.3
Dark Yellow Boaldi	10.0	26.5	10.5	9.9	15.6
Yuba	13.1	23.6	17.1	12.1	17.9
Davis	25.1	29.0	18.1	21.8	17.1
Miramar	21.1	13.9	10.7	13.5	10.1
Tan	18.0	19.9	8.0	8.3	13.8
Statistical mean	16.8	22.6	13.7	13.4	15.2

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

All figures represent mean values of 10 replicate pots per plot

Table 6. Effect of L.D. and S.D. supplementary lighting treatment on bud development (assessed at standard marketing stage)

Variety	Average number of buds at stages 3 and 4 relative to lighting treatment				
	a	b	c	d	e
Stick date: Week 41					
Charm	9.0	5.5	13.5	11.9	11.4
Dark Yellow Boaldi	25.7	26.2	24.3	26.6	24.1
Yuba	26.3	34.5	16.6	19.5	19.5
Davis	33.7	33.2	33.3	37.9	32.9
Miramar	19.2	21.9	16.4	24.2	12.0
Tan	13.4	13.8	16.8	16.9	12.3
Stick date: Week 45					
Charm	9.5	10.5	7.2	7.2	8.2
Dark Yellow Boaldi	18.5	25.0	15.6	21.9	14.9
Yuba	15.1	21.3	6.9	11.5	14.7
Davis	18.0	25.2	15.4	14.9	16.0
Miramar	11.9	15.9	8.3	10.5	10.3
Tan	12.0	12.4	10.1	9.7	10.8
Stick date: Week 49					
Charm	12.4	11.2	10.5	16.0	10.2
Dark Yellow Boaldi	31.1	29.9	19.5	25.8	22.5
Yuba	21.6	26.7	21.7	24.9	24.8
Davis	20.9	19.9	24.4	22.2	21.5
Miramar	15.3	18.4	15.5	10.9	19.8
Tan	14.0	13.6	13.3	18.3	17.9
Statistical mean	18.2	20.3	16.1	18.4	16.9

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

All figures represent mean values of 10 replicate pots per plot

Table 7. Effect of L.D. and S.D. supplementary lighting treatment on bud development (assessed at standard marketing stage)

Variety	Average number of buds at stage 5 and above relative to lighting treatment				
	a	b	c	d	e
Stick date: Week 41					
Charm	8.0	10.6	8.5	6.8	6.7
Dark Yellow Boaldi	7.2	9.7	11.0	10.1	10.7
Yuba	8.0	8.3	6.5	7.9	8.3
Davis	12.5	9.8	13.2	10.4	14.2
Miramar	8.4	14.1	9.8	6.1	10.5
Tan	6.3	5.5	5.0	7.1	5.7
Stick date: Week 45					
Charm	5.6	5.2	5.5	5.4	6.2
Dark Yellow Boaldi	6.6	5.6	7.0	6.0	6.6
Yuba	5.9	6.4	4.3	5.0	5.1
Davis	5.2	6.4	5.0	4.8	5.4
Miramar	5.9	6.7	8.4	6.4	5.3
Tan	6.0	4.0	4.0	4.5	3.9
Stick date: Week 49					
Charm	4.5	5.1	7.1	6.3	9.1
Dark Yellow Boaldi	8.7	6.3	9.0	7.6	9.2
Yuba	6.0	5.0	7.4	5.0	6.1
Davis	6.4	11.8	7.0	6.7	7.8
Miramar	3.9	8.5	7.6	6.7	6.4
Tan	6.8	5.5	11.1	10.1	11.2
Statistical mean	6.8	7.5	7.6	6.8	7.7

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

All figures represent mean values of 10 replicate pots per plot

Table 8. Effect of L.D. and S.D. supplementary lighting treatment on total bud count (assessed at standard marketing stage)

Variety	Total bud count per pot relative to lighting treatment				
	a	b	c	d	e
Stick date: Week 41					
Charm	38.6	44.5	41.5	44.9	39.4
Dark Yellow Boaldi	49.5	54.7	44.2	49.2	46.2
Yuba	49.0	51.1	36.3	36.8	43.8
Davis	65.1	73.2	67.8	61.8	65.2
Miramar	38.7	46.3	33.5	42.3	33.8
Tan	53.1	60.7	48.5	42.7	53.6
Stick date: Week 45					
Charm	30.4	40.3	25.3	24.9	26.7
Dark Yellow Boaldi	31.4	47.0	27.5	32.5	23.7
Yuba	33.0	41.7	20.8	24.5	27.4
Davis	41.1	50.7	34.4	32.2	35.1
Miramar	31.3	39.2	24.3	28.8	27.7
Tan	27.7	47.9	33.3	33.3	30.4
Stick date: Week 49					
Charm	40.9	50.7	34.0	36.8	40.6
Dark Yellow Boaldi	40.8	62.7	39.0	43.3	47.3
Yuba	40.7	55.3	46.2	42.0	48.8
Davis	52.4	60.7	49.5	50.7	46.4
Miramar	40.3	40.8	33.8	31.1	36.3
Tan	38.8	39.0	32.4	36.8	42.9
Statistical mean	41.8	50.4	39.7	38.6	37.4

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

All figures represent mean values of 10 replicate pots per plot

Table 9. Effect of L.D. and S.D. supplementary lighting treatment on uniformity of flowering (average maximum bud stage per plant) (assessed at standard marketing stage)

Variety	Average maximum bud stage per plant relative to lighting treatment				
	a	b	c	d	e
Stick date: Week 41					
Charm	6.1	6.0	5.9	5.9	5.6
Dark Yellow Boaldi	5.5	6.2	6.1	5.9	6.3
Yuba	5.4	5.3	5.2	5.6	5.6
Davis	5.6	6.2	6.1	5.6	5.8
Miramar	6.1	6.0	6.3	5.8	5.7
Tan	5.4	5.0	5.1	5.5	5.1
Stick date: Week 45					
Charm	5.2	5.2	5.4	5.2	5.6
Dark Yellow Boaldi	4.9	4.8	4.9	4.7	5.1
Yuba	4.9	5.5	4.8	5.1	5.2
Davis	4.9	5.2	5.0	5.0	4.9
Miramar	5.6	5.1	5.2	5.3	5.0
Tan	5.3	5.0	5.0	5.2	5.1
Stick date: Week 49					
Charm	4.6	5.1	5.4	5.4	5.9
Dark Yellow Boaldi	4.9	4.6	5.2	5.3	5.2
Yuba	5.1	4.6	5.2	5.4	5.1
Davis	5.1	5.7	5.3	5.0	5.2
Miramar	5.0	5.6	5.2	5.9	5.0
Tan	5.6	5.5	5.8	6.3	5.7
Statistical mean	5.3	5.4	5.4	5.4	5.4

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

All figures represent mean values of 10 replicate pots per plot

APPENDIX IV

MAIN TRIAL: Assessment of Marketing Stage and its Potential Interaction with Supplementary Lighting on Shelf Life - Tables of Results

Table 1. Effect of L.D. and S.D. supplementary lighting treatment on post production shelf life

Stick Date: Week 41

Variety	Bud deterioration score relative to lighting treatment				
	a	b	c	d	e
Marketing Stage 1					
Charm	23.3	26.0	32.6	19.3	32.8
Dark Yellow Boaldi	59.1	55.1	54.3	58.3	65.6
Davis	39.6	76.8	49.2	110.9	47.5
Miramar	32.7	30.4	31.6	39.8	23.2
Marketing Stage 2					
Charm	40.6	31.2	39.3	36.1	37.2
Dark Yellow Boaldi	106.5	68.9	61.3	63.9	84.5
Davis	87.9	54.7	91.5	85.3	99.1
Miramar	33.7	43.9	46.2	44.0	54.2
Marketing Stage 3					
Charm	46.7	44.8	50.4	48.1	40.3
Dark Yellow Boaldi	143.7	121.5	72.3	72.1	69.5
Davis	77.4	90.9	85.6	133.6	115.6
Miramar	57.9	73.9	98.1	98.6	60.6
Statistical mean	62.4	59.8	59.4	67.5	60.8

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

All figures represent mean values of 4 replicate pots per plot.

Bud deterioration score* = (7 x nD1) + (4 x nD2) + (nD3)
and
D1 = partial deterioration D2 = moderate deterioration D3 = severe deterioration

* Refer to page 26 for a full description of this score

Table 2. Effect of L.D. and S.D. supplementary lighting treatment on post production shelf life

Stick Date: Week 45

Variety	Bud deterioration score relative to lighting treatment				
	a	b	c	d	e
Marketing Stage 1					
Charm	28.3	33.8	19.8	30.3	29.5
Dark Yellow Boaldi	44.4	60.1	43.6	53.0	43.5
Davis	50.1	71.2	28.6	48.0	59.5
Miramar	25.3	22.5	23.7	21.4	20.9
Marketing Stage 2					
Charm	20.8	21.8	25.5	37.8	40.3
Dark Yellow Boaldi	46.2	43.4	50.7	46.6	47.2
Davis	57.2	67.3	54.8	61.5	44.0
Miramar	46.2	40.0	25.0	40.7	33.9
Marketing Stage 3					
Charm	38.6	33.0	31.3	28.7	44.2
Dark Yellow Boaldi	61.7	98.9	43.4	64.7	29.7
Davis	88.4	123.8	84.3	78.1	75.3
Miramar	48.3	62.6	41.5	54.5	34.7
Statistical mean	46.3	56.5	39.3	47.1	41.9

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

All figures represent mean values of 4 replicate pots per plot.

Bud deterioration score* = (7 x nD1) + (4 x nD2) + (nD3)
and
D1 = partial deterioration D2 = moderate deterioration D3 = severe deterioration

* Refer to page 26 for a full description of this score

Table 3. Effect of L.D. and S.D. supplementary lighting treatment on post production shelf life

Stick Date: Week 49

Variety	Bud deterioration score relative to lighting treatment				
	a	b	c	d	e
Marketing Stage 1					
Charm	22.3	39.7	54.9	35.9	44.6
Dark Yellow Boaldi	112.1	73.8	69.9	70.5	63.2
Davis	103.8	99.1	101.9	117.2	117.6
Miramar	44.6	33.5	52.7	27.3	43.7
Marketing Stage 2					
Charm	50.3	42.5	49.8	48.7	63.9
Dark Yellow Boaldi	121.6	94.7	65.5	93.0	112.4
Davis	97.6	90.6	118.4	109.0	100.8
Miramar	49.8	34.3	31.0	54.4	38.1
Marketing Stage 3					
Charm	92.1	44.8	57.0	57.8	80.1
Dark Yellow Boaldi	172.7	178.6	133.9	128.5	159.3
Davis	131.6	152.8	214.2	154.9	179.4
Miramar	66.4	51.1	44.9	89.4	47.8
Statistical mean	88.7	77.9	82.8	82.2	87.6

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

All figures represent mean values of 4 replicate pots per plot.

Bud deterioration score* = (7 x nD1) + (4 x nD2) + (nD3)
and
D1 = partial deterioration D2 = moderate deterioration D3 = severe deterioration

* Refer to page 26 for a full description of this score

Table 4. Effect of L.D. and S.D. supplementary lighting treatment on post production shelf life

Stick Date: Week 41

Variety	Bud opening score				
	a	b	c	d	e
Marketing Stage 1					
Charm	2.0	2.6	2.1	2.8	2.0
Dark Yellow Boaldi	3.7	3.5	4.1	3.6	3.7
Davis	3.6	3.3	4.1	2.4	3.9
Miramar	3.2	2.6	3.3	3.2	2.5
Marketing Stage 2					
Charm	2.7	2.8	3.0	2.6	2.7
Dark Yellow Boaldi	3.4	3.4	3.9	3.6	3.5
Davis	3.7	3.9	3.5	3.7	3.5
Miramar	3.1	3.1	3.5	3.2	2.8
Marketing Stage 3					
Charm	2.7	2.5	2.4	2.6	2.4
Dark Yellow Boaldi	3.1	3.6	4.0	3.4	3.8
Davis	3.7	4.0	3.6	3.3	3.6
Miramar	2.6	3.6	2.9	2.7	2.7
Statistical mean	3.3	3.4	3.6	3.3	3.4

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

All figures represent mean values of 4 replicate pots per plot.

$$\text{Bud opening score}^* = \frac{(nB1\&2) + (4 \times nB3\&4) + (7 \times nB5+)}{(nB1\&2) + (nB3\&4) + (nB5+)}$$

Where B1 to B5 refers to bud stages as defined by Cockshull and Hughes (1972).

* Refer to page 29 for a full description of this score

Table 5. Effect of L.D. and S.D. supplementary lighting treatment on post production shelf life

Stick Date: Week 45

Variety	Bud opening score				
	a	b	c	d	e
Marketing Stage 1					
Charm	3.0	2.8	2.9	3.0	2.6
Dark Yellow Boaldi	4.5	3.8	4.3	5.3	4.5
Davis	4.1	4.2	4.0	4.2	4.1
Miramar	3.6	3.8	4.1	4.1	4.4
Marketing Stage 2					
Charm	3.0	3.2	3.1	3.2	3.3
Dark Yellow Boaldi	4.1	4.4	4.7	4.6	5.0
Davis	4.2	4.0	4.3	4.5	4.3
Miramar	4.1	4.2	5.0	4.2	4.7
Marketing Stage 3					
Charm	3.9	3.2	3.2	4.1	3.7
Dark Yellow Boaldi	5.3	4.9	5.3	6.1	6.1
Davis	4.3	4.5	5.2	5.9	5.5
Miramar	5.0	5.2	4.9	5.0	5.0
Statistical mean	4.3	4.2	4.5	4.8	4.7

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

All figures represent mean values of 4 replicate pots per plot.

$$\text{Bud opening score}^* = \frac{(nB1\&2) + (4 \times nB3\&4) + (7 \times nB5+)}{(nB1\&2) + (nB3\&4) + (nB5+)}$$

Where B1 to B5 refers to bud stages as defined by Cockshull and Hughes (1972).

* Refer to page 29 for a full description of this score

Table 6. Effect of L.D. and S.D. supplementary lighting treatment on post production shelf life

Stick Date: Week 49

Variety	Bud opening score				
	a	b	c	d	e
Marketing Stage 1					
Charm	2.1	2.2	2.2	2.8	2.3
Dark Yellow Boaldi	3.2	2.3	3.2	3.0	2.9
Davis	3.5	2.8	3.9	3.7	3.5
Miramar	3.8	3.2	4.2	4.2	4.2
Marketing Stage 2					
Charm	3.5	2.8	3.3	3.4	3.1
Dark Yellow Boaldi	3.1	3.0	3.7	3.3	2.9
Davis	3.6	3.1	5.3	3.7	3.4
Miramar	4.5	4.0	5.0	4.3	4.0
Marketing Stage 3					
Charm	4.0	3.4	3.8	4.5	3.6
Dark Yellow Boaldi	4.9	4.5	4.4	3.8	3.3
Davis	5.7	3.9	4.3	4.9	4.4
Miramar	4.9	4.6	5.3	5.3	5.2
Statistical mean	4.0	3.3	4.0	3.9	3.6

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

All figures represent mean values of 4 replicate pots per plot.

$$\text{Bud opening score}^* = \frac{(nB1\&2) + (4 \times nB3\&4) + (7 \times nB5+)}{(nB1\&2) + (nB3\&4) + (nB5+)}$$

Where B1 to B5 refers to bud stages as defined by Cockshull and Hughes (1972).

* Refer to page 29 for a full description of this score

APPENDIX V

OBSERVATION TRIAL: Combined Influence of Supplementary Lighting and Growth Regulants on Production Time and Plant Form - Tables of Results

Table 1. Influence of supplementary lighting at 2000 lux throughout S.D. and its interaction with the use of growth regulants on production time and plant form

Variety: Yuba +/- alar

Treatment	Crop duration	Plant height	Mean spread (cm)
Stick Date: Week 41			
Unlit + alar	69.8	16.5	27.5
Unlit - alar	69.5	19.9	29.8
2000 lux + alar	69.2	18.9	27.9
2000 lux - alar	69.9	21.3	29.9
Stick Date: Week 45			
Unlit + alar	77.3	17.6	31.6
Unlit - alar	76.7	20.1	32.1
2000 lux + alar	71.6	15.6	30.6
2000 lux - alar	74.4	19.5	32.1
Stick Date: Week 49			
Unlit + alar	78.9	19.4	31.2
Unlit - alar	78.3	19.5	30.3
2000 lux + alar	74.5	15.9	27.8
2000 lux - alar	73.9	18.0	30.2

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

Table 2. Influence of supplementary lighting at 2000 lux throughout S.D. and its interaction with the use of growth regulants on production time and plant form

Variety: Charm +/- phosphon

Treatment	Crop duration	Plant height	Mean spread (cm)
Stick Date: Week 41			
Unlit + phosphon	68.5	13.7	27.4
Unlit - phosphon	67.2	15.6	28.9
2000 lux + phosphon	67.9	14.0	32.2
2000 lux - phosphon	66.6	16.0	32.2
Stick Date: Week 45			
Unlit + phosphon	72.8	13.7	29.3
Unlit - phosphon	72.6	15.4	31.7
2000 lux + phosphon	69.2	12.9	29.5
2000 lux - phosphon	68.4	15.8	30.8
Stick Date: Week 49			
Unlit + phosphon	77.7	15.1	29.0
Unlit - phosphon	76.5	16.8	29.8
2000 lux + phosphon	73.7	14.0	29.3
2000 lux - phosphon	72.2	16.4	28.8

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

Table 3. Influence of supplementary lighting at 2000 lux throughout S.D. and its interaction with the use of growth regulants on flower development

Variety: Yuba +/- alar

Variety	Average number at bud stage 1+2	3+4	≤5	Average maximum bud stage per pot
Stick Date: Week 41				
Unlit + alar	14.9	20.5	7.8	5.4
Unlit - alar	11.1	19.0	8.5	5.7
2000 lux + alar	12.9	28.1	9.2	5.7
2000 lux - alar	16.5	25.0	6.1	5.1
Stick Date: Week 45				
Unlit + alar	14.7	12.4	4.5	5.1
Unlit - alar	10.5	13.2	5.6	5.5
2000 lux + alar	11.7	25.9	7.0	5.7
2000 lux - alar	11.5	23.4	8.1	5.9
Stick Date: Week 49				
Unlit + alar	7.7	25.1	6.7	5.4
Unlit - alar	8.8	23.1	6.6	5.1
2000 lux + alar	12.1	26.1	8.8	5.5
2000 lux - alar	8.7	30.2	12.9	6.1

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

Table 4. Influence of supplementary lighting at 2000 lux throughout S.D. and its interaction with the use of growth regulants on flower development

Variety: Charm +/- phosphon

Variety	Average number at bud stage 1+2	3+4	≤5	Average maximum bud stage per pot
Stick Date: Week 41				
Unlit + phosphon	12.2	10.2	10.5	6.3
Unlit - phosphon	15.1	9.2	10.1	6.2
2000 lux + phosphon	28.8	10.7	7.7	5.8
2000 lux - phosphon	24.7	9.8	9.1	6.1
Stick Date: Week 45				
Unlit + phosphon	14.6	7.5	6.5	5.5
Unlit - phosphon	12.7	8.7	9.7	6.5
2000 lux + phosphon	24.5	10.3	5.4	5.1
2000 lux - phosphon	26.5	11.6	6.0	5.1
Stick Date: Week 49				
Unlit + phosphon	19.7	13.8	6.3	5.2
Unlit - phosphon	21.7	12.0	6.7	5.6
2000 lux + phosphon	24.8	12.0	11.3	6.4
2000 lux - phosphon	25.3	10.3	11.2	6.4

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

APPENDIX VI

COMPOST ANALYSES

Table 1. Effect of L.D. and S.D. supplementary lighting treatment and marketing stage on peat compost extractable nutrients

Variety - Charm
Stick date - Week 41

Treatment & Sampling date		pH	Cond μS	NO_3-N mg/l	NH_4 mg/l N	P mg/l	K mg/l	Mg mg/l
a	mid	5.8	164	8	0.4	22	114	41
	end	5.5	208	74	1.0	23	26	76
	sl1	-	-	-	-	-	-	
	sl2	6.0	95	12	1.0	12	22	20
	sl3	6.2	75	4	3.0	15	32	14
b	mid	6.1	123	20	2.0	16	11	38
	end	6.3	78	13	0.0	8	10	23
	sl1	6.7	69	3	3.0	8	18	12
	sl2	6.6	79	0	1.0	9	24	15
	sl3	6.4	60	3	0.0	10	26	9
c	mid	5.9	109	11	1.0	13	18	28
	end	5.7	221	78	2.0	23	35	77
	sl1	-	-	-	-	-	-	-
	sl2	6.0	137	27	1.0	17	33	28
	sl3	5.9	150	46	0.0	15	57	33
d	mid	6.3	108	0	0.4	9	2	19
	end	6.3	69	4	0.0	8	7	21
	sl1	6.5	100	0	1.0	10	17	16
	sl2	6.6	105	5	1.0	14	27	22
	sl3	6.6	59	4	0.0	7	11	9
e	mid	5.9	128	4	0.4	16	4	38
	end	5.9	129	42	0.0	12	12	40
	sl1	-	-	-	-	-	-	-
	sl2	6.1	98	12	1.0	11	22	18
	sl3	6.3	75	4	2.0	9	24	10

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

Sampling date

mid	mid crop
end	end crop
sl1	end of shelf life (marketing stage 1 pots)
sl2	end of shelf life (marketing stage 2 pots)
sl3	end of shelf life (marketing stage 3 pots)

Table 2. **Effect of L.D. and S.D. supplementary lighting treatment and marketing stage on peat compost extractable nutrients**

Variety - Charm
Stick date - Week 45

Treatment & sampling date		pH	Cond μS	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
a	mid	5.6	260	72	3.0	35	8	108
	end	5.7	226	63	1.0	27	6	88
	sl1	6.3	109	13	1.0	15	26	23
	sl2	6.5	53	4	3.0	2	10	3
	sl3	6.6	55	4	6.0	2	7	7
b	mid	5.4	320	108	3.0	38	15	125
	end	5.6	211	74	0.0	17	21	63
	sl1	5.9	206	67	1.0	19	31	56
	sl2	6.0	210	56	0.0	15	21	60
	sl3	6.0	189	63	1.0	12	24	46
c	mid	5.5	237	71	3.0	32	18	94
	end	5.5	254	95	3.0	32	45	86
	sl1	6.1	136	40	4.0	15	45	35
	sl2	5.8	217	66	3.0	25	37	72
	sl3	5.8	203	60	2.0	28	38	71
d	mid	5.7	247	75	3.0	30	30	92
	end	5.9	204	60	7.0	19	20	66
	sl1	6.1	201	53	1.0	25	36	68
	sl2	6.2	116	25	3.0	7	39	25
	sl3	6.2	132	26	1.0	12	29	32
e	mid	5.7	241	66	1.0	29	8	96
	end	5.5	185	57	7.0	26	16	59
	sl1	5.8	266	74	4.0	30	29	98
	sl2	6.2	145	18	2.0	16	9	47
	sl3	6.1	131	17	3.0	16	17	39

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

Sampling date

mid	mid crop
end	end of crop
sl1	end of shelf life (marketing stage 1 pots)
sl2	end of shelf life (marketing stage 2 pots)
sl3	end of shelf life (marketing stage 3 pots)

Table 3. Effect of L.D. and S.D supplementary lighting treatment and marketing stage on peat compost extractable nutrients

Variety - Charm
Stick date - Week 49

Treatment & sampling date		pH	Cond μS	NO_3-N mg/l	NH_4-N mg/l N	P mg/l	K mg/l	Mg mg/l
a	mid	5.2	347	111	5.0	73	82	130
	end	5.1	224	94	0.0	20	10	73
	sl1	5.3	261	89	1.0	38	18	98
	sl2	5.4	329	114	1.0	35	9	116
	sl3	5.6	280	66	0.4	33	12	105
b	mid	5.2	249	80	3.0	46	37	94
	end	5.8	320	143	0.0	38	36	115
	sl1	5.3	320	109	0.0	40	27	106
	sl2	5.5	155	39	2.0	21	11	50
	sl3	5.8	121	17	0.4	13	0	33
c	mid	5.4	182	27	4.0	48	31	50
	end	5.4	227	87	1.0	24	41	67
	sl1	5.4	206	49	2.0	35	21	70
	sl2	5.3	245	81	1.0	36	29	84
	sl3	5.2	278	88	2.0	24	22	89
d	mid	5.4	195	32	3.0	45	14	67
	end	5.3	167	59	3.0	20	25	47
	sl1	5.6	243	43	3.0	35	25	91
	sl2	5.5	254	93	3.0	24	17	89
	sl3	5.3	344	131	0.4	37	20	125
e	mid	5.3	235	46	3.0	52	23	82
	end	4.6	173	58	1.0	18	22	48
	sl1	5.2	317	106	2.0	39	21	121
	sl2	5.2	306	136	1.0	31	9	119
	sl3	5.4	235	83	2.0	29	14	82

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. unlit
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

Sampling date

mid	mid crop
end	end crop
sl1	end of shelf life (marketing stage 1 pots)
sl2	end of shelf life (marketing stage 2 pots)
sl3	end of shelf life (marketing stage 3 pots)

Table 4. Effect of L.D. and S.D. supplementary lighting treatment and marketing stage on peat compost extractable nutrients

Variety - Dark Yellow Boaldi
Stick date - Week 41

Treatment & sampling date		pH	Cond μS	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
a	mid	6.3	105	1	1.0	11	3	30
	end	6.3	134	19	2.0	9	21	36
	sl1	6.5	138	9	2.0	7	30	28
	sl2	6.4	202	15	2.0	8	27	52
	sl3	6.5	176	9	0.0	8	43	43
b	mid	6.0	232	23	1.0	22	17	81
	end	6.4	118	16	0.0	7	12	35
	sl1	6.6	144	3	1.0	6	34	33
	sl2	6.7	113	11	0.0	4	28	22
	sl3	6.5	171	7	3.0	6	22	47
c	mid	6.1	162	22	0.4	15	10	49
	end	6.4	171	35	0.0	5	34	43
	sl1	6.4	197	27	1.0	9	34	50
	sl2	6.4	206	14	0.0	5	33	46
	sl3	6.4	195	18	1.0	6	26	51
d	mid	6.3	109	14	3.0	8	19	21
	end	6.4	94	0	0.0	11	20	22
	sl1	6.4	139	0	1.0	8	16	32
	sl2	6.4	122	1	0.0	11	20	27
	sl3	6.7	135	5	0.0	8	19	27
e	mid	6.3	120	7	3.0	10	5	32
	end	6.2	176	41	0.0	15	42	50
	sl1	-	-	-	-	-	-	-
	sl2	6.5	124	16	3.0	12	43	24
	sl3	6.2	284	51	0.0	18	53	84

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

Sampling date

mid	mid crop
end	end crop
sl1	end of shelf life (marketing stage 1 pots)
sl2	end of shelf life (marketing stage 2 pots)
sl3	end of shelf life (marketing stage 3 pots)

Table 5. Effect of L.D. and S.D. supplementary lighting treatment and marketing stage on peat compost extractable nutrients

Variety - Dark Yellow Boaldi
Stick date - Week 45

Treatment & sampling date		pH	Cond μS	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
a	mid	5.5	359	87	1.0	30	32	139
	end	5.3	289	102	7.0	16	17	99
	sl1	5.6	391	134	2.0	21	29	153
	sl2	5.9	289	71	1.0	14	31	101
	sl3	6.0	255	88	3.0	11	59	75
b	mid	5.5	309	91	1.0	30	24	119
	end	5.4	315	109	3.0	31	43	94
	sl1	5.7	329	125	18.0	28	46	126
	sl2	5.8	260	76	1.0	15	35	84
	sl3	5.9	278	90	3.0	23	37	99
c	mid	5.6	297	78	4.0	31	11	119
	end	5.6	191	66	5.0	13	19	62
	sl1	5.8	299	80	1.0	21	24	108
	sl2	5.9	308	102	3.0	19	37	115
	sl3	6.0	183	45	1.0	11	44	48
d	mid	5.8	220	39	3.0	18	10	82
	end	5.7	218	55	1.0	14	21	62
	sl1	6.1	305	51	1.0	8	20	109
	sl2	6.5	134	19	2.0	1	23	32
	sl3	6.2	289	35	3.0	10	25	105
e	mid	5.7	255	60	3.0	28	8	101
	end	5.6	322	118	2.0	27	40	107
	sl1	5.9	218	50	3.0	19	30	77
	sl2	5.8	291	60	3.0	17	26	109
	sl3	6.1	202	45	13.0	17	28	67

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

Sampling date

mid	mid crop
end	end crop
sl1	end of shelf life (marketing stage 1 pots)
sl2	end of shelf life (marketing stage 2 pots)
sl3	end of shelf life (marketing stage 3 pots)

Table 6. Effect of L.D. and S.D. supplementary lighting treatment and marketing stage on peat compost extractable nutrients

Variety - Dark Yellow Boaldi
Stick date - Week 49

Treatment & Sampling date		pH	Cond μS	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
a	mid	5.2	324	91	4.0	65	80	109
	end	4.8	280	96	3.0	18	13	92
	sl1	5.2	475	173	2.0	32	28	179
	sl2	5.5	321	92	3.0	28	11	121
	sl3	5.7	279	68	0.4	25	14	94
b	mid	5.3	270	84	4.0	48	43	94
	end	5.0	306	129	3.0	26	28	98
	sl1	5.3	353	141	1.0	38	39	117
	sl2	5.6	199	77	1.0	8	12	60
	sl3	5.4	435	181	0.4	20	26	137
c	mid	5.3	234	38	5.0	52	33	85
	end	5.1	226	89	1.0	16	45	61
	sl1	5.0	388	154	0.0	42	56	138
	sl2	5.3	307	110	0.0	33	37	108
	sl3	5.4	339	131	2.0	40	38	115
d	mid	5.4	230	49	4.0	47	32	84
	end	5.2	303	114	2.0	31	43	96
	sl1	5.5	289	86	4.0	43	25	102
	sl2	5.3	374	127	1.0	43	49	128
	sl3	5.3	321	108	2.0	37	31	112
e	mid	5.3	266	62	3.0	45	44	82
	end	5.2	218	78	1.0	16	37	57
	sl1	5.4	290	101	3.0	27	36	102
	sl2	5.2	375	132	3.0	35	38	130
	sl3	5.7	305	91	0.4	13	4	105

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

Sampling date

mid	mid crop
end	end crop
sl1	end of shelf life (marketing stage 1 pots)
sl2	end of shelf life (marketing stage 2 pots)
sl3	end of shelf life (marketing stage 3 pots)

Table 7. Effect of L.D. and S.D. supplementary lighting treatment and marketing stage on peat compost extractable nutrients

Variety - Yuba
Stick date - Week 41

Treatment & sampling date		pH	Cond μS	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
a	mid	6.2	91	1	1.00	13	5	29
	end	6.3	76	1	0.00	11	7	16
b	mid	6.1	141	16	3.0	20	20	43
	end	6.5	74	8	1.0	9	6	13
c	mid	6.2	118	8	5.0	21	17	31
	end	6.3	108	15	0.0	14	21	22
d	mid	6.1	150	8	4.0	25	15	48
	end	6.4	74	1	0.0	15	11	17
e	mid	6.1	109	0	3.0	16	13	30
	end	6.4	68	2	0.0	13	14	12

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

Sampling date

mid	mid crop
end	end crop

Table 8. Effect of L.D. and S.D. supplementary lighting treatment and marketing stage on peat compost extractable nutrients

Variety - Yuba
Stick date - Week 45

Treatment & sampling date		pH	Cond μS	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
a	mid	5.6	243	75	3.0	37	23	92
	end	5.6	195	56	2.0	23	16	80
b	mid	5.6	217	73	3.0	32	26	80
	end	5.4	244	83	4.0	27	35	80
c	mid	5.6	193	49	3.0	65	35	66
	end	5.7	177	48	2.0	20	22	50
d	mid	5.6	147	35	4.0	22	16	50
	end	6.1	99	14	2.0	10	22	17
e	mid	5.6	174	38	1.0	35	13	70
	end	5.9	105	19	1.0	17	15	31

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 2000 lux weeks 1 and 2

Sampling date

mid	mid crop
end	end crop

Table 9. **Effect of L.D. and S.D. supplementary lighting treatment and marketing stage on peat compost extractable nutrients**

Variety - Yuba
Stick date - Week 49

Treatment & sampling date		pH	Cond μS	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
a	mid	5.4	261	104	4.0	53	65	98
	end	5.5	186	86	0.0	19	28	59
b	mid	5.5	229	100	4.0	38	50	73
	end	5.7	161	79	0.0	15	29	33
c	mid	5.7	200	66	3.0	41	23	82
	end	5.7	118	43	0.0	14	34	28
d	mid	5.8	125	34	3.0	27	13	49
	end	5.6	146	49	1.0	17	28	40
e	mid	5.6	202	71	3.0	41	29	79
	end	5.2	139	49	3.0	17	26	37

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

Sampling date

mid	mid crop
end	end crop

Table 10. Effect of L.D. and S.D. supplementary lighting treatment and marketing stage on peat compost extractable nutrients

Variety - Davis
Stick date - Week 41

Treatment & sampling date		pH	Cond μS	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
a	mid	6.0	182	23	0.8	15	9	61
	end	6.4	95	2	0.0	5	4	26
	sl1	6.4	139	22	1.0	6	14	36
	sl2	6.3	203	8	1.0	5	5	64
	sl3	6.2	228	7	2.0	7	9	74
b	mid	6.1	167	33	3.0	16	20	52
	end	6.2	208	40	0.0	17	30	66
	sl1	6.6	73	2	1.0	8	12	16
	sl2	6.3	113	7	1.0	12	21	27
	sl3	6.4	174	2	0.0	11	19	51
c	mid	6.1	177	30	3.0	11	15	53
	end	6.1	196	55	0.0	10	37	60
	sl1	6.5	130	6	2.0	4	24	26
	sl2	6.4	187	34	1.0	10	17	12
	sl3	6.3	172	29	0.0	11	46	45
d	mid	6.2	117	0	3.0	13	6	36
	end	6.3	183	35	7.0	13	35	33
	sl1	6.4	130	0	1.0	8	24	28
	sl2	6.4	132	12	1.0	10	25	30
	sl3	6.3	149	7	3.0	36	56	35
e	mid	6.3	84	4	2.0	10	3	27
	end	6.3	89	0	0.0	8	14	18
	sl1	6.4	155	5	1.0	8	11	40
	sl2	6.4	138	3	1.0	5	16	36
	sl3	6.5	115	2	0.0	10	26	35

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

Sampling date

mid	mid crop
end	end crop
sl1	end of shelf life (marketing stage 1 pots)
sl2	end of shelf life (marketing stage 2 pots)
sl3	end of shelf life (marketing stage 3 pots)

Table 11. Effect of L.D. and S.D. supplementary lighting treatment and marketing stage on peat compost extractable nutrients

Variety - Davis
Stick date - Week 45

Treatment & sampling date		pH	Cond μS	NO_3-N mg/l	NH_4-N mg/l N	P mg/l	K mg/l	Mg mg/l
a	mid	5.3	292	107	1.0	22	20	106
	end	5.5	196	66	2.0	10	1	65
	sl1	5.4	389	140	16.0	34	23	151
	sl2	5.4	278	107	1.0	23	12	104
	sl3	5.6	327	113	16.0	13	13	121
b	mid	5.6	213	72	5.0	33	18	79
	end	5.3	202	83	0.0	22	23	62
	sl1	5.9	194	52	5.0	17	18	65
	sl2	5.9	142	39	1.0	17	15	45
	sl3	5.8	164	54	1.0	23	17	53
c	mid	5.6	233	181	4.0	28	18	90
	end	5.5	301	109	0.0	22	19	109
	sl1	5.7	283	76	2.0	21	17	110
	sl2	5.7	348	106	15.0	30	21	144
	sl3	5.8	301	93	5.0	25	27	109
d	mid	5.5	256	95	10.0	30	28	95
	end	5.5	279	104	0.0	25	14	104
	sl1	6.0	199	63	2.0	13	41	58
	sl2	5.8	278	95	5.0	26	31	101
	sl3	5.9	146	40	2.0	12	29	47
e	mid	5.5	334	93	6.0	48	15	146
	end	5.4	263	102	2.0	21	22	91
	sl1	5.6	199	67	1.0	18	17	68
	sl2	5.8	310	95	5.0	25	26	132
	sl3	5.9	229	64	1.0	23	21	81

Lighting treatment

a L.D. unlit	S.D. unlit
b L.D. unlit	S.D. 2000 lux throughout
c L.D. unlit	S.D. 5000 lux throughout
d L.D. lit (2 weeks)	S.D. 5000 lux throughout
e L.D. unlit	S.D. 5000 lux throughout

Sampling date

mid	mid crop
end	end of crop
sl1	end of shelf life (marketing stage 1 pots)
sl2	end of shelf life (marketing stage 2 pots)
sl3	end of shelf life (marketing stage 3 pots)

Table 12. Effect of L.D. and S.D. supplementary lighting treatment and marketing stage on peat compost extractable nutrients

Variety - Davis
Stick date - Week 49

Treatment & sampling date		pH	Cond μS	NO_3-N mg/l	NH_4-N mg/l N	P mg/l	K mg/l	Mg mg/l
a	mid	5.5	356	148	1.0	60	80	136
	end	5.4	333	150	4.0	20	9	123
	sl1	5.4	351	189	2.0	26	23	124
	sl2	5.4	409	201	2.0	30	20	149
	sl3	5.5	397	189	0.4	35	7	155
b	mid	5.3	315	160	1.0	36	60	112
	end	5.2	288	157	3.0	26	52	78
	sl1	5.6	283	141	1.0	28	28	96
	sl2	5.5	357	221	4.0	33	40	134
	sl3	5.5	348	218	3.0	29	15	127
c	mid	5.6	297	111	2.0	41	24	120
	end	5.5	342	170	1.0	23	38	113
	sl1	5.5	340	164	1.0	25	34	116
	sl2	5.5	309	156	0.0	26	25	108
	sl3	5.6	257	140	0.0	19	49	74
d	mid	5.7	210	73	3.0	29	34	74
	end	5.7	293	121	3.0	28	27	105
	sl1	5.4	424	204	0.0	40	33	144
	sl2	6.2	154	33	0.0	19	14	47
	sl3	5.7	257	114	0.0	24	24	87
e	mid	5.7	205	66	1.0	36	23	77
	end	5.0	154	68	0.0	15	15	50
	sl1	5.5	383	171	0.0	35	19	144
	sl2	6.2	102	33	0.0	7	14	26
	sl3	5.8	268	106	0.0	24	15	95

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

Sampling date

mid	mid crop
end	end of crop
sl1	end of shelf life (marketing stage 1 pots)
sl2	end of shelf life (marketing stage 2 pots)
sl3	end of shelf life (marketing stage 3 pots)

Table 13. Effect of L.D. and S.D. supplementary lighting treatment and marketing stage on peat compost extractable nutrients

Variety - Miramar
Stick date - Week 41

Treatment & sampling date		pH	Cond μS	NO_3-N mg/l	NH_4-N mg/l N	P mg/l	K mg/l	Mg mg/l
a	mid	5.6	192	29	1.0	24	15	55
	end	5.3	156	21	0.0	20	19	39
	sl1	5.6	99	8	1.0	13	21	17
	sl2	6.2	148	2	0.0	12	21	33
	sl2	5.7	74	9	1.0	8	14	26
b	mid	6.1	175	21	2.0	19	17	54
	end	6.3	103	12	0.0	9	14	21
	sl1	-	-	-	-	-	-	-
	sl2	6.1	82	0	1.0	10	16	12
	sl3	6.6	74	0	1.0	2	5	10
c	mid	6.0	119	24	1.0	12	12	27
	end	5.9	188	43	3.0	19	36	52
	sl1	-	-	-	-	-	-	-
	sl2	5.5	103	23	0.0	7	27	19
	sl3	5.8	156	26	3.0	8	16	39
d	mid	6.1	140	25	1.0	19	19	39
	end	6.3	144	9	0.0	14	14	35
	sl1	6.4	118	0	0.0	10	14	25
	sl2	6.4	150	3	0.0	11	13	36
	sl3	6.3	145	3	2.0	12	9	38
e	mid	6.0	177	12	1.0	19	8	36
	end	5.5	142	32	1.0	17	24	33
	sl1	-	-	-	-	-	-	-
	sl2	5.5	117	11	0.0	5	5	21
	sl3	6.1	89	3	2.0	7	12	12

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

Sampling date

mid	mid crop
end	end crop
sl1	end of shelf life (marketing stage 1 pots)
sl2	end of shelf life (marketing stage 2 pots)
sl3	end of shelf life (marketing stage 3 pots)

Table 14. Effect of L.D. and S.D. supplementary lighting treatment and marketing stage on peat compost extractable nutrients

Variety - Miramar
Stick date - Week 45

Treatment & sampling date		pH	Cond μS	NO_3-N mg/l	NH4-N mg/l	P mg/l	K mg/l	Mg mg/l
a	mid	5.5	334	76	8.0	25	32	79
	end	5.5	237	72	0.0	22	20	80
	sl1	5.6	256	91	2.0	20	44	78
	sl2	6.0	176	36	1.0	17	22	52
	sl3	6.1	182	58	7.0	12	14	64
b	mid	5.6	210	59	6.0	27	20	73
	end	5.3	307	129	0.0	22	53	93
	sl1	5.5	327	104	3.0	31	38	118
	sl2	5.8	230	64	1.0	23	35	69
	sl3	6.0	212	62	3.0	18	27	69
c	mid	5.6	237	70	6.0	28	20	86
	end	5.7	304	82	0.0	27	15	111
	sl1	5.9	259	40	2.0	19	30	84
	sl2	6.1	217	35	6.0	14	20	73
	sl3	6.1	195	49	6.0	13	30	61
d	mid	5.7	238	49	10.0	32	13	93
	end	6.1	143	24	0.0	11	15	45
	sl1	5.4	199	40	1.0	10	32	61
	sl2	6.0	216	37	1.0	24	32	67
	sl3	6.3	161	15	2.0	15	18	45
e	mid	5.6	197	49	4.0	27	18	72
	end	5.5	256	82	0.0	19	25	88
	sl1	6.3	123	25	1.0	9	40	29
	sl2	6.1	153	20	1.0	7	16	40
	sl3	6.0	179	37	1.0	15	24	47

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

Sampling date

mid	mid crop
end	end crop
sl1	end of shelf life (marketing stage 1 pots)
sl2	end of shelf life (marketing stage 2 pots)
sl3	end of shelf life (marketing stage 3 pots)

Table 15. Effect of L.D. and S.D. supplementary lighting treatment and marketing stage on peat extractable nutrients

Variety - Mirimar
Stick date - Week 49

Treatment & sampling date		pH	Cond μS	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
a	mid	5.5	325	134	1.0	60	84	126
	end	5.1	292	125	1.0	34	28	111
	sl1	5.8	248	102	0.0	27	81	24
	sl2	5.6	308	129	0.0	33	101	30
	sl3	5.6	366	159	0.4	32	140	9
b	mid	5.4	325	150	2.0	49	74	121
	end	5.4	294	147	3.0	27	51	86
	sl1	5.7	263	123	0.0	17	42	77
	sl2	5.5	404	193	0.0	47	63	146
	sl3	5.3	407	199	0.0	39	51	136
c	mid	5.6	287	108	1.0	57	52	118
	end	5.3	253	120	1.0	20	41	79
	sl1	5.5	311	153	0.0	25	46	104
	sl2	5.2	357	173	0.0	32	52	117
	sl3	5.5	350	168	0.0	38	59	121
d	mid	5.6	223	60	4.0	46	20	98
	end	5.4	232	106	1.0	17	42	65
	sl1	5.7	316	135	0.0	32	38	112
	sl2	5.7	252	102	0.0	24	18	87
	sl3	5.8	254	97	0.4	29	39	83
e	mid	5.6	235	86	2.0	48	46	87
	end	4.8	255	111	1.0	28	31	88
	sl1	6.0	174	70	0.0	19	32	50
	sl2	5.8	223	87	0.0	22	41	66
	sl3	5.8	207	76	0.0	30	36	65

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

Sampling date

mid	mid crop
end	end crop
sl1	end of shelf life (marketing stage 1 pots)
sl2	end of shelf life (marketing stage 2 pots)
sl3	end of shelf life (marketing stage 3 pots)

Table 16. Effect of L.D. and S.D. supplementary lighting treatment and marketing stage on peat compost extractable nutrients

Variety - Tan
Stick date - Week 41

Treatment & sampling date		pH	Cond μS	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
a	mid	5.7	90	8	0.4	9	0	23
	end	5.4	111	29	4.0	8	9	26
b	mid	5.9	140	24	2.0	14	13	43
	end	6.3	127	15	0.0	6	6	30
c	mid	6.0	166	31	0.4	12	8	53
	end	5.7	143	33	2.0	12	10	40
d	mid	6.0	164	34	2.0	16	17	49
	end	6.2	176	24	1.0	14	7	53
e	mid	5.5	124	27	1.0	14	30	35
	end	5.3	185	71	0.0	12	20	56

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (2 weeks)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

Sampling date

mid	mid crop
end	end crop

Table 17. Effect of L.D. and S.D. supplementary lighting treatment and marketing stage on peat compost extractable nutrients

Variety - Tan
Stick date - Week 45

Treatment & sampling date		pH	Cond μS	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
a	mid	5.5	255	95	9.0	26	27	91
	end	5.6	228	82	0.0	12	7	86
b	mid	5.5	234	91	9.0	19	23	80
	end	5.2	355	150	2.0	18	21	128
c	mid	5.6	49	43	11.0	34	27	49
	end	5.6	185	61	0.0	11	12	63
d	mid	5.6	223	67	9.0	19	23	74
	end	5.7	191	60	2.0	13	14	65
e	mid	5.3	246	39	12.0	28	22	89
	end	5.4	302	112	2.0	29	40	104

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

Sampling date

mid	mid crop
end	end crop

Table 18. Effect of L.D. and S.D. supplementary lighting treatment and marketing stage on peat compost extractable nutrients

Variety - Tan
Stick date - Week 49

Treatment & sampling date		pH	Cond μS	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
a	mid	5.4	408	172	1.0	64	112	151
	end	5.4	263	138	2.0	14	20	92
b	mid	5.2	343	166	1.0	40	82	123
	end	4.8	430	242	3.0	26	82	136
c	mid	5.4	329	143	2.0	39	44	130
	end	5.1	391	203	3.0	25	51	137
d	mid	5.4	321	129	3.0	40	42	125
	end	5.0	504	255	2.0	39	74	185
e	mid	5.5	285	113	3.0	45	63	108
	end	5.3	318	148	0.0	32	31	115

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

Sampling date

mid	mid crop
end	end crop

Table 19. Influence of supplementary lighting at 2000 lux throughout S.D. and its interaction with the use of growth regulants on peat compost extractable nutrients

Varieties: Yuba and Charm
Stick date - week 41

Treatment & sampling date		pH	Cond μS	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
Q	mid	-	-	-	-	-	-	-
	end	5.7	97	16	0.0	11	11	23
R	mid	-	-	-	-	-	-	-
	end	5.6	118	5	0.0	18	5	35
S	mid	-	-	-	-	-	-	-
	end	5.9	99	19	2.0	11	22	24
T	mid	-	-	-	-	-	-	-
	end	5.7	97	17	4.0	11	20	18
V	mid	-	-	-	-	-	-	-
	end	6.3	130	13	0.0	8	7	32
W	mid	-	-	-	-	-	-	-
	end	5.7	174	9	1.0	8	5	58
X	mid	-	-	-	-	-	-	-
	end	6.0	116	5	1.0	7	5	22
Y	mid	-	-	-	-	-	-	-
	end	5.7	88	16	2.0	9	5	20

Treatment

Q	Yuba	unlit	+	alar
R	Yuba	unlit	-	alar
S	Yuba	2000 lux	+	alar
T	Yuba	2000 lux	-	alar
V	Charm	unlit	+	phosphon
W	Charm	unlit	-	phosphon
X	Charm	2000 lux	+	phosphon
Y	Charm	2000 lux	-	phosphon

Sampling date

mid	mid crop
end	end crop

Table 20. **Influence of supplementary lighting at 2000 lux throughout S.D. and its interaction with the use of growth regulants on peat compost extractable nutrients**

Varieties: Yuba and Charm
Stick date - week 45

Treatment & sampling date		pH	Cond μS	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
Q	mid	5.5	207	60	0.0	39	27	75
	end	5.6	173	35	2.0	27	13	64
R	mid	5.5	182	54	4.0	32	18	63
	end	5.7	157	40	0.0	22	21	51
S	mid	5.3	279	106	5.0	35	47	92
	end	5.4	241	93	2.0	30	42	79
T	mid	5.5	238	84	7.0	36	27	85
	end	5.4	263	97	2.0	28	30	93
V	mid	5.6	262	79	3.0	39	16	99
	end	5.9	158	30	2.0	16	4	58
W	mid	5.6	217	62	2.0	32	13	82
	end	5.6	185	51	3.0	15	12	65
X	mid	5.7	214	66	2.0	31	15	83
	end	5.6	170	60	2.0	23	19	55
Y	mid	5.3	228	76	1.0	31	13	93
	end	5.1	320	142	2.0	25	47	106

Treatment

Q	Yuba	unlit	+	alar
R	Yuba	unlit	-	alar
S	Yuba	2000 lux	+	alar
T	Yuba	2000 lux	-	alar
V	Charm	unlit	+	phosphon
W	Charm	unlit	-	phosphon
X	Charm	2000 lux	+	phosphon
Y	Charm	2000 lux	-	phosphon

Sampling date

mid	mid crop
end	end crop

Table 21. **Influence of supplementary lighting at 2000 lux throughout S.D. and its interaction with the use of growth regulants on peat compost extractable nutrients**

Varieties: Yuba and Charm
Stick date - week 49

Treatment & sampling date		pH	Cond μS	NO_3-N mg/l	NH_4-N mg/l	P mg/l	K mg/l	Mg mg/l
Q	mid	5.3	247	100	2.0	34	54	87
	end	5.3	174	68	0.0	13	10	54
R	mid	5.4	255	89	2.0	66	50	94
	end	5.2	266	105	0.0	21	15	97
S	mid	5.3	275	118	1.0	46	57	102
	end	5.4	216	95	0.0	30	42	67
T	mid	5.3	347	148	2.0	54	78	133
	end	5.2	322	153	1.0	40	60	103
V	mid	5.2	226	48	3.0	51	31	90
	end	5.1	255	89	0.0	25	13	85
W	mid	5.4	234	83	3.0	38	43	83
	end	5.5	193	70	1.0	19	19	65
X	mid	4.9	416	173	12.0	57	86	151
	end	4.8	303	138	1.0	23	52	77
Y	mid	5.1	447	202	3.0	55	104	163
	end	5.2	310	159	0.0	24	42	99

Treatment

Q	Yuba	unlit	+	alar
R	Yuba	unlit	-	alar
S	Yuba	2000 lux	+	alar
T	Yuba	2000 lux	-	alar
V	Charm	unlit	+	phosphon
W	Charm	unlit	-	phosphon
X	Charm	2000 lux	+	phosphon
Y	Charm	2000 lux	-	phosphon

Sampling date

mid	mid crop
end	end crop

APPENDIX VII

LEAF ANALYSES

Table 1. Leaf analyses at marketing relative to supplementary lighting treatment

Variety: Charm

Stick date	Lighting treatment	Leaf analyses DM Oven %	Total N %	Total P %	Total K %	Total Mg %	Total Mn mg/kg
41	a	9.2	5.72	1.17	5.29	0.80	370
45	a	9.3	5.71	1.40	6.33	0.80	380
49	a	8.7	5.75	1.14	6.38	0.75	360
41	b	6.0	5.65	1.28	4.53	0.71	310
45	b	4.9	6.08	1.17	6.67	0.75	375
49	b	8.2	5.98	1.10	6.68	0.83	345
41	c	8.6	5.61	1.32	4.15	0.82	325
45	c	8.2	5.96	1.33	6.19	0.88	383
49	c	7.2	5.79	1.43	6.30	0.90	370
41	d	8.6	4.69	1.39	3.65	0.68	310
45	d	8.0	5.57	1.52	5.52	0.92	375
49	d	7.9	5.42	1.22	5.84	0.80	320
41	e	8.6	5.23	0.94	4.14	0.78	310
45	e	7.2	5.75	1.46	6.69	0.80	383
49	e	11.0	5.47	1.11	4.90	0.90	325

Lighting treatments:

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

Nutrient element ranges recommended as "sufficient" for chrysanthemums (Peterson, 1982)

% Total N - 4.0 to 6.5	% Total Mg - 0.35 to 0.65
% Total P - 0.3 to 1.0	mg/kg Total Mn - 3.0 to 300
% Total K - 4.5 to 6.5	

Table 2. Leaf analyses at marketing relative to supplementary lighting treatment

Variety: Dark Yellow Boaldi

Stick date	Lighting treatment	Leaf analyses DM Oven %	Total N %	Total P %	Total K %	Total Mg %	Total Mn mg/kg
41	a	6.8	6.03	1.49	4.87	0.90	295
45	a	7.5	6.52	1.84	7.24	1.04	370
49	a	6.3	6.20	1.37	6.72	0.73	320
41	b	7.1	6.11	1.56	4.99	0.83	280
45	b	4.5	6.39	1.71	6.73	0.90	335
49	b	6.4	6.61	1.45	7.02	0.65	340
41	c	7.1	6.09	1.59	3.97	1.05	330
45	c	6.6	6.38	1.82	6.32	0.91	365
49	c	5.4	5.95	1.65	6.85	0.88	360
41	d	7.7	5.72	1.21	4.85	1.18	430
45	d	6.4	6.21	1.71	5.70	1.05	333
49	d	7.1	5.77	1.42	5.98	0.98	355
41	e	8.3	5.58	1.48	3.90	1.00	340
45	e	6.5	6.44	1.93	7.14	0.98	410
49	e	7.8	6.10	1.68	6.33	0.93	295

Lighting treatments:

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

Nutrient element ranges recommended as "sufficient" for chrysanthemums (Peterson, 1982)

% Total N - 4.0 to 6.5
% Total P - 0.3 to 1.0
% Total K - 4.5 to 6.5
% Total Mg - 0.35 to 0.65
mg/kg Total Mn - 3.0 to 300

Table 3. Leaf analyses at marketing relative to supplementary lighting treatment

Variety: Yuba

Stick date	Lighting treatment	Leaf analyses DM Oven %	Total N %	Total P %	Total K %	Total Mg %	Total Mn mg/kg
41	a	7.5	5.20	1.28	4.08	1.10	360
45	a	7.0	5.84	1.28	5.83	1.38	493
49	a	8.5	5.48	0.99	5.78	1.20	465
41	b	8.0	5.49	1.24	3.64	1.09	395
45	b	8.5	5.77	1.12	4.99	1.50	493
49	b	7.8	5.63	0.99	5.26	1.28	410
41	c	7.8	5.39	1.20	4.09	1.15	405
45	c	7.7	5.66	1.19	5.59	1.45	448
49	c	7.5	5.28	1.19	4.72	1.33	440
41	d	8.4	5.01	1.30	3.36	1.06	375
45	d	7.2	5.29	0.99	5.36	1.33	325
49	d	9.7	5.42	0.98	4.68	1.05	440
41	e	8.1	5.28	1.44	3.67	1.24	425
45	e	8.4	5.73	1.25	5.70	1.43	438
49	e	10.6	5.68	1.05	4.71	1.20	440

Lighting treatments:

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

Nutrient element ranges recommended as "sufficient" for chrysanthemums (Peterson, 1982)

% Total N - 4.0 to 6.5	% Total Mg - 0.35 to 0.65
% Total P - 0.3 to 1.0	mg/kg Total Mn - 3.0 to 300
% Total K - 4.5 to 6.5	

Table 4. Leaf analyses at marketing relative to supplementary lighting treatment

Variety: Davis

Stick date	Lighting treatment	Leaf analyses DM Oven %	Total N %	Total P %	Total K %	Total Mg %	Total Mn mg/kg
41	a	6.8	5.57	1.47	5.22	0.89	285
45	a	6.6	5.94	1.41	7.79	0.98	375
49	a	7.8	6.05	1.30	7.52	1.05	350
41	b	6.8	5.56	1.47	5.37	0.84	310
45	b	7.3	5.92	1.55	7.39	0.96	423
49	b	8.2	5.99	0.88	6.92	0.88	265
41	c	7.3	5.55	1.49	5.00	0.93	325
45	c	7.4	6.06	1.33	7.50	1.15	335
49	c	7.8	6.07	1.34	6.56	1.25	405
41	d	8.6	5.66	1.38	4.96	0.85	330
45	d	7.1	5.76	1.59	6.99	1.06	373
49	d	9.2	5.53	1.29	5.88	1.28	345
41	e	7.1	5.38	1.53	4.98	0.95	305
45	e	6.7	5.99	1.68	7.37	1.10	380
49	e	7.2	6.22	1.04	6.68	1.43	340

Lighting treatments:

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

Nutrient element ranges recommended as "sufficient" for chrysanthemums (Peterson, 1982)

% Total N - 4.0 to 6.5	% Total Mg - 0.35 to 0.65
% Total P - 0.3 to 1.0	mg/kg Total Mn - 3.0 to 300
% Total K - 4.5 to 6.5	

Table 5. Leaf analyses at marketing relative to supplementary lighting treatment

Variety: Miramar

Stick date	Lighting treatment	Leaf analyses DM Oven %	Total N %	Total P %	Total K %	Total Mg %	Total Mn mg/kg
41	a	7.4	5.36	1.21	4.45	1.00	430
45	a	6.9	6.27	1.38	6.65	1.25	500
49	a	9.1	6.12	1.14	5.86	1.28	525
41	b	7.5	5.85	1.29	5.04	1.15	440
45	b	7.7	6.09	1.19	5.89	1.13	415
49	b	9.1	6.12	0.98	5.77	1.18	410
41	c	8.1	5.87	1.01	4.63	1.13	415
45	c	7.5	6.19	1.53	6.22	1.30	530
49	c	7.2	6.00	1.12	5.38	1.23	465
41	d	7.8	5.46	1.49	4.20	1.05	330
45	d	7.2	5.96	1.62	5.24	1.20	465
49	d	7.5	5.72	1.24	5.92	1.20	450
41	e	8.4	5.31	1.08	4.65	1.13	430
45	e	7.1	6.03	1.45	6.56	1.18	478
49	e	8.2	5.80	1.07	6.21	1.15	440

Lighting treatments:

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

Nutrient element ranges recommended as "sufficient" for chrysanthemums (Peterson, 1982)

% Total N - 4.0 to 6.5	% Total Mg - 0.35 to 0.65
% Total P - 0.3 to 1.0	mg/kg Total Mn - 3.0 to 300
% Total K - 4.5 to 6.5	

Table 6. Leaf analyses at marketing relative to supplementary lighting treatment

Variety: Tan

Stick date	Lighting treatment	Leaf analyses DM Oven %	Total N %	Total P %	Total K %	Total Mg %	Total Mn mg/kg
41	a	6.9	5.56	1.50	5.09	0.88	255
45	a	5.7	5.92	1.97	7.53	0.80	365
49	a	6.5	5.98	1.73	7.53	0.85	345
41	b	7.5	5.44	1.16	5.14	0.76	245
45	b	7.3	5.83	1.77	7.44	0.79	328
49	b	8.2	5.88	1.85	6.91	0.88	340
41	c	7.9	5.17	1.64	4.48	0.95	325
45	c	7.2	5.65	1.71	6.84	0.90	300
49	c	8.1	5.84	1.84	6.84	0.88	340
41	d	7.8	5.41	1.67	4.68	0.98	275
45	d	7.4	5.46	2.16	6.58	0.89	345
49	d	7.7	5.77	1.95	7.04	0.80	345
41	e	7.7	5.52	1.63	5.04	0.99	280
45	e	7.5	5.78	1.92	7.41	0.84	333
49	e	7.3	5.87	1.78	7.63	0.90	390

Lighting treatments:

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

Nutrient element ranges recommended as "sufficient" for chrysanthemums (Peterson, 1982)

% Total N - 4.0 to 6.5	% Total Mg - 0.35 to 0.65
% Total P - 0.3 to 1.0	mg/kg Total Mn - 3.0 to 300
% Total K - 4.5 to 6.5	

Table 7. Leaf analyses at marketing relative to the interaction between 2000 lux SD supplementary lighting and chemical growth regulators

Variety: Charm

Stick date	Treatment			Leaf analyses DM Oven %	Total N %	Total P %	Total K %	Total Mg %	Total Mn mg/kg
41	Unlit	+	phosphon	8.2	5.47	1.48	4.78	0.86	305
45	Unlit	+	phosphon	9.7	5.52	1.44	5.92	0.83	373
49	Unlit	+	phosphon	8.6	5.59	1.35	6.05	0.93	370
41	Unlit	-	phosphon	7.6	5.62	1.55	4.59	0.94	350
45	Unlit	-	phosphon	7.3	5.49	1.39	5.98	0.88	370
49	Unlit	-	phosphon	5.1	5.32	1.14	5.88	0.88	350
41	2000 lux	+	phosphon	8.6	5.59	0.92	4.45	0.66	270
45	2000 lux	+	phosphon	8.0	5.88	1.24	6.11	0.86	360
49	2000 lux	+	phosphon	10.3	6.11	1.19	6.17	1.18	340
41	2000 lux	-	phosphon	8.8	5.30	1.08	4.25	0.74	300
45	2000 lux	-	phosphon	9.2	6.03	1.30	6.17	0.78	375
49	2000 lux	-	phosphon	7.4	5.75	0.97	5.98	0.98	310

Nutrient element ranges recommended as "sufficient" for chrysanthemums (Peterson, 1982)

% Total N - 4.0 to 6.5
% Total P - 0.3 to 1.0
% Total K - 4.5 to 6.5
% Total Mg - 0.35 to 0.65
mg/kg Total Mn - 3.0 to 300

Table 8. Leaf analyses at marketing relative to the interaction between 2000 lux SD supplementary lighting and chemical growth regulators

Variety: Yuba

Stick date	Treatment	Leaf analyses DM Oven %	Total N %	Total P %	Total K %	Total Mg %	Total Mn mg/kg
41	Unlit + alar	7.9	5.74	1.30	4.78	1.23	440
45	Unlit + alar	7.6	5.44	1.28	5.13	1.50	458
49	Unlit + alar	6.2	5.31	1.00	4.50	1.33	460
41	Unlit - alar	8.1	5.26	1.24	3.97	1.30	455
45	Unlit - alar	7.5	5.34	1.20	5.16	1.30	455
49	Unlit - alar	7.7	5.42	0.95	5.04	1.35	445
41	2000 lux + alar	8.2	5.26	1.25	4.29	1.28	440
45	2000 lux + alar	8.4	5.74	1.18	5.43	1.40	465
49	2000 lux + alar	5.5	5.78	0.89	5.83	1.48	420
41	2000 lux - alar	8.7	4.57	1.10	3.67	1.20	360
45	2000 lux - alar	8.0	5.79	1.15	5.31	1.25	500
49	2000 lux - alar	9.6	5.94	0.84	5.88	1.45	435

Nutrient element ranges recommended as "sufficient" for chrysanthemums (Peterson, 1982)

% Total N - 4.0 to 6.5
% Total P - 0.3 to 1.0
% Total K - 4.5 to 6.5
% Total Mg - 0.35 to 0.65
mg/kg Total Mn - 3.0 to 300

COSTING SUMMARY FOR THE SUPPLEMENTARY LIGHTING OF POT CHRYSANTHEMUMS IN WINTER

From:

HDC PC13b (1991/92)
HDC PC13c (1992/93)
HDC PC92 (1993/94)

INTRODUCTION

The following summary includes economic evaluations calculated for pot chrysanthemum lighting treatments which have been evaluated at HRI Efford over recent years. It has been necessary to base these figures on assumptions regarding capital costs and electricity charges. These assumptions are provided below each table but will need adjusting according to individual circumstances.

An amendment to the costings presented in PC13c (1992/93) is also attached to this summary.

SUMMARY OF POT CHRYSANTHEMUM LIGHTING AND SPACING TREATMENTS

LIGHTING COSTS PER POT
1991/92, 1992/93, 1993/94

	2nd Wk LD	SD1	SD2	SD3	SD4-Flwg	Yr of Trial	Cost Assumption A Capital p/pot	Cost Assumption A Running p/pot	Cost Assumption A Total p/pot	Cost Assumption B Capital p/pot	Cost Assumption B Running p/pot	Cost Assumption B Total p/pot
1 TREATMENT	(ANNES)											
Lighting	NIL	5000	5000	5000	NIL	1991/92	5.0	8.2	13.2	4.3	5.8	10.1
Spacing pots/m²	41	16	16	11.5	11.5							
2 TREATMENT	(ANNES)											
Lighting	NIL	5000	5000	NIL	NIL	1991/92	3.4	5.5	8.9	2.9	3.9	6.8
Spacing pots/m²	41	16	16	11.5	11.5							
3a TREATMENT												
Lighting	5000	5000	5000	5000	NIL	1991/92	5.8	9.1	14.9	5.1	6.5	11.6
Spacing pots/m²	41	24	24	12.5	12.5							
3b TREATMENT												
Lighting	5000	5000	5000	5000	NIL	1991/92	5.7	9.2	14.9	5.0	6.6	11.6
Spacing pots/m²	41	18	18	18	12.5							
4a TREATMENT												
Lighting	5000	5000	5000	NIL	NIL	1992/93	3.6	5.6	9.2	3.2	4.0	7.2
Spacing pots/m²	41	24	24	12.5	12.5							
4b TREATMENT												
Lighting	5000	5000	5000	NIL	NIL	1992/93	4.4	6.8	11.2	3.8	4.9	8.7
Spacing pots/m²	41	18	18	18	12.5							

Treatments as shown in individual reports. Treatment using 5000 lux (12 W/m²) in S.D. No. 1 onwards. Treatments using 2000 lux (4.8 W/m²) in S.D. No. 10 onwards.
Cost Assumption A: Installed cost of 400 SON/T lamps £160. Interest rate 14%. Electricity Cost 0700 to 23.59 = 7.78p/kWh. 0.00 to 06.59 = 2.61p/kWh
Cost Assumption B: Installed cost of 400 SON/T lamps £150. Interest rate 9%. Electricity Cost 0700 to 23.59 = 5.50p/kWh. 0.00 to 06.59 = 3.00p/kWh

SUMMARY OF POT CHRYSANTHEMUM LIGHTING AND SPACING TREATMENTS

LIGHTING COSTS PER POT
1991/92, 1992/93, 1993/94

	2nd Wk LD	SD1	SD2	SD3	SD4-Flwg	Yr of Trial	Cost Assumption A Capital p/pot	Cost Assumption A Running p/pot	Cost Assumption A Total p/pot	Cost Assumption B Capital p/pot	Cost Assumption B Running p/pot	Cost Assumption B Total p/pot
5a TREATMENT												
Lighting	NIL	5000	5000	5000	NIL	1991/92, 92/93, 93/94	4.5	7.2	11.7	3.9	5.1	9.0
Spacing pots/m²	41	24	24	12.5	12.5							
5b TREATMENT												
Lighting	NIL	5000	5000	5000	NIL	1991/92, 92/93, 93/94	4.4	7.3	11.7	3.8	5.2	9.0
Spacing pots/m²	41	18	18	18	12.5							
5c TREATMENT												
Lighting	NIL	5000	5000	5000	NIL	1993/94	3.6	5.8	9.4	3.2	4.1	7.3
Spacing pots/m²	41	30	30	15	15							
5d TREATMENT												
Lighting	NIL	5000	5000	5000	NIL	1993/94	3.5	5.9	9.4	3.1	4.1	7.2
Spacing pots/m²	41	22.5	22.5	22.5	15							
6a TREATMENT												
Lighting	NIL	5000	5000	NIL	NIL	1992/93	2.3	3.7	6.0	2.0	2.6	4.6
Spacing pots/m²	41	24	24	12.5	12.5							
6b TREATMENT												
Lighting	NIL	5000	5000	NIL	NIL	1992/93	3.1	4.9	8.0	2.7	3.5	6.2
Spacing pots/m²	41	18	18	18	12.5							

Treatments as shown in individual reports. Treatment using 5000 lux (12 W/m²) in S.D. No. 1 onwards. Treatments using 2000 lux (4.8 W/m²) in S.D. No. 10 onwards.
Cost Assumption A: Installed cost of 400 SON/T lamps £160. Interest rate 14%. Electricity Cost 0700 to 23.59 = 7.78p/kWh. 0.00 to 06.59 = 2.61p/kWh
Cost Assumption B: Installed cost of 400 SON/T lamps £150. Interest rate 9%. Electricity Cost 0700 to 23.59 = 5.50p/kWh. 0.00 to 06.59 - 3.00p/kWh

SUMMARY OF POT CHRYSANTHEMUM LIGHTING AND SPACING TREATMENTS

LIGHTING COSTS PER POT
1991/92, 1992/93, 1993/94

	2nd Wk LD	SD1	SD2	SD3	SD4-Flwg	Yr of Trial	Cost Assumption A Capital p/pot	Cost Assumption A Running p/pot	Cost Assumption A Total p/pot	Cost Assumption B Capital p/pot	Cost Assumption B Running p/pot	Cost Assumption B Total p/pot
10 TREATMENT	(ANNES)											
Lighting	NIL	2000	2000	2000	2000	1991/92	8.8	13.3	22.1	7.6	9.4	17.0
Spacing pots/m²	41	16	16	11.5	11.5							
11 TREATMENT												
Lighting	5000	2000	2000	2000	2000	1991/92	8.4	12.5	20.9	7.3	8.9	16.2
Spacing pots/m²	41	24	24	12.5	12.5							
12a TREATMENT												
Lighting	NIL	2000	2000	2000	2000	1991/92,	7.1	10.6	17.7	6.2	7.5	13.7
Spacing pots/m²	41	24	24	12.5	12.5	92/93, 93/94						
12b TREATMENT												
Lighting	NIL	2000	2000	2000	2000	1993/94	5.9	8.8	14.7	5.1	6.2	11.3
Spacing pots/m²	41	30	30	15	15							

Treatments as shown in individual reports. Treatment using 5000 lux (12 W/m²) in S.D. No. 1 onwards. Treatments using 2000 lux (4.8 W/m²) in S.D. No. 10 onwards.
Cost Assumption A: Installed cost of 400 SON/T lamps £160. Interest rate 14%. Electricity Cost 0700 to 23.59 = 7.78p/kWh. 0.00 to 06.59 = 2.61p/kWh
Cost Assumption B: Installed cost of 400 SON/T lamps £150. Interest rate 9%. Electricity Cost 0700 to 23.59 = 5.50p/kWh. 0.00 to 06.59 = 3.00p/kWh

NOTIFICATION OF AMENDMENT TO REPORT PC13c (1992/93)

(Chrysanthemums: The influence of supplementary lighting on winter quality and shelf-life of American bred varieties of pot `mums')

Appendix VIII, page 97 of the above mentioned report includes a copy of costings calculated for report PC13b (Chrysanthemums: Supplementary lighting for winter production of pot chrysanthemums). These costings did not however cover all the treatments relevant to the PC13c and so summary costing figures are presented in the following to fully represent those treatments.

C. Overall cost of treatment

Yoder varieties

Without L.D. Lighting

		Capital p/pot	Running p/pot	Total p/pot
a.	5000 lux for first 3 weeks of S.D. 2 weeks at 24 pots/m² and 1 week at 12.5 pots/m²	4.5	7.2	11.7
	Alternatively: 5000 lux for first 3 weeks of S.D. at 18 pots/m²	4.4	7.3	11.7
b.	2000 lux throughout S.D.	7.1	10.6	17.7
c.	5000 lux for first 2 weeks S.D. at 24 pots/m²	2.3	3.7	6.0
	Alternatively: 5000 lux for first 2 weeks S.D. at 18 pots/m²	3.1	4.9	8.0

With L.D. Lighting for 1 week at 5000 lux

		Capital	Running	Total
a.	plus 5000 lux for first 2 weeks of S.D. 2 weeks at 24 pots/m²	1.3+2.3	1.9+3.7	9.2
	Alternatively: plus 5000 lux for first 2 weeks of S.D. at 18 pots/m²	1.3+3.1	1.9+4.9	11.2

(Note: capital costs of L.D. lighting may be halved if mobile lights or benches are used giving a total additional cost of 2.6 p/pot).

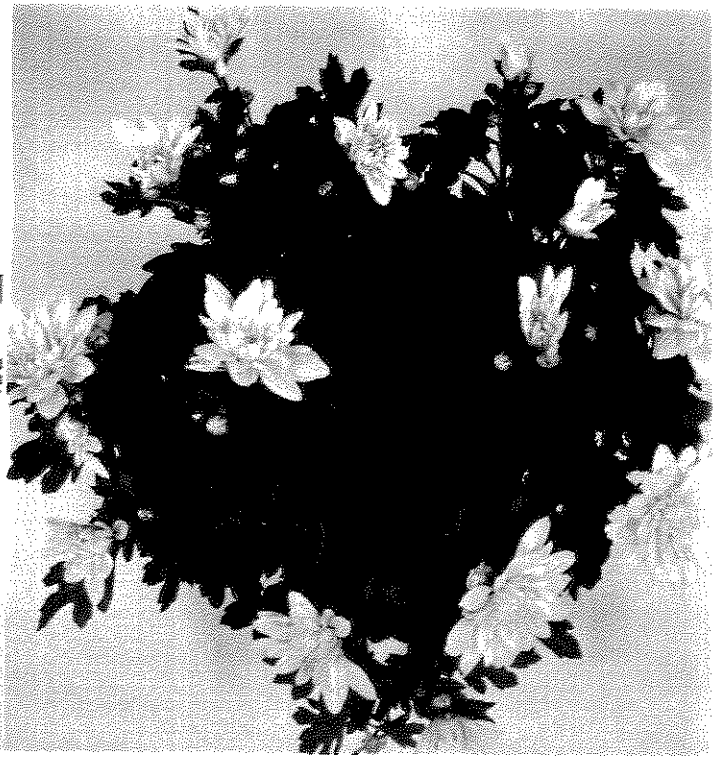
APPENDIX IX

PHOTOGRAPHIC RECORDS

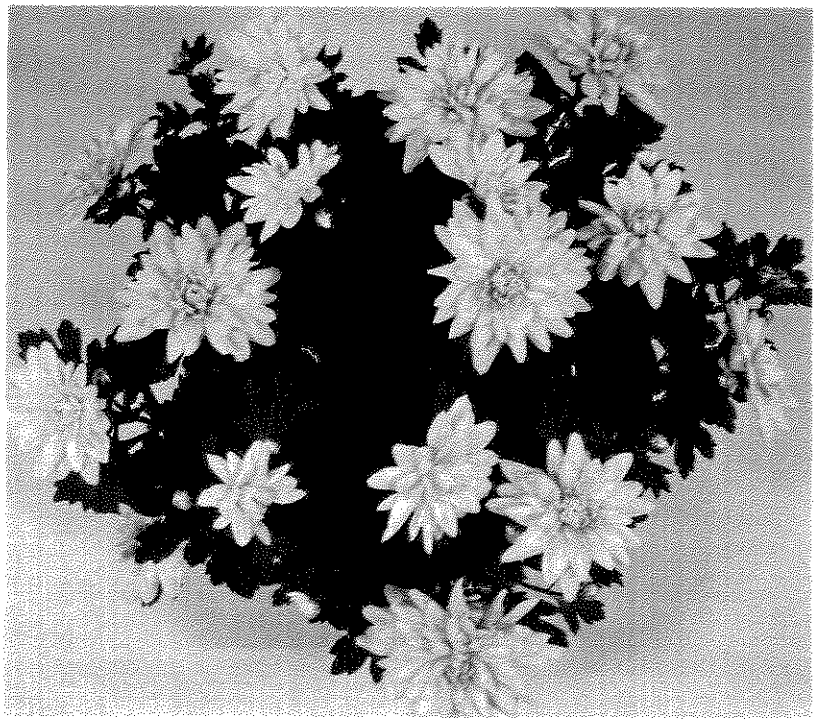
Plate 1

Illustration of marketing stages for Charm

Stage 1
7-12 flowers showing colour
7 flowers with petals 10mm long
and upright



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



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

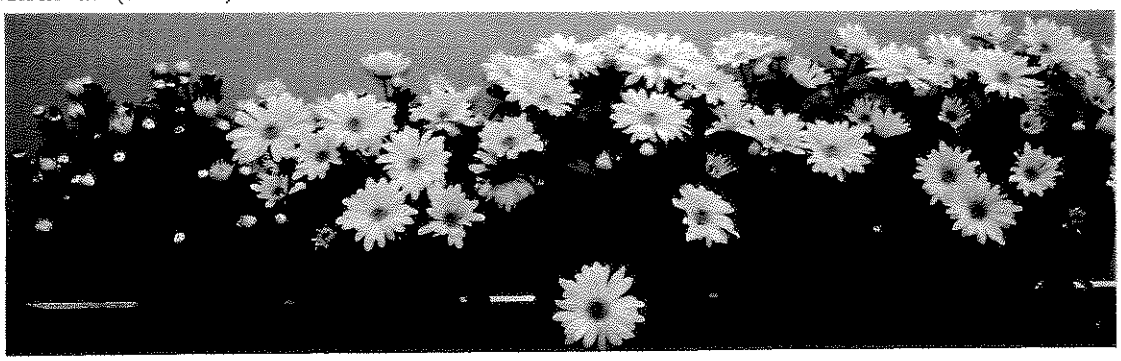
Plate 2

Main trial. Influence of supplementary lighting on winter quality

Davis (week 49)

a b c d e

Miramar (week 49)



a b c d e

Tan (week 49)

a b c d e

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

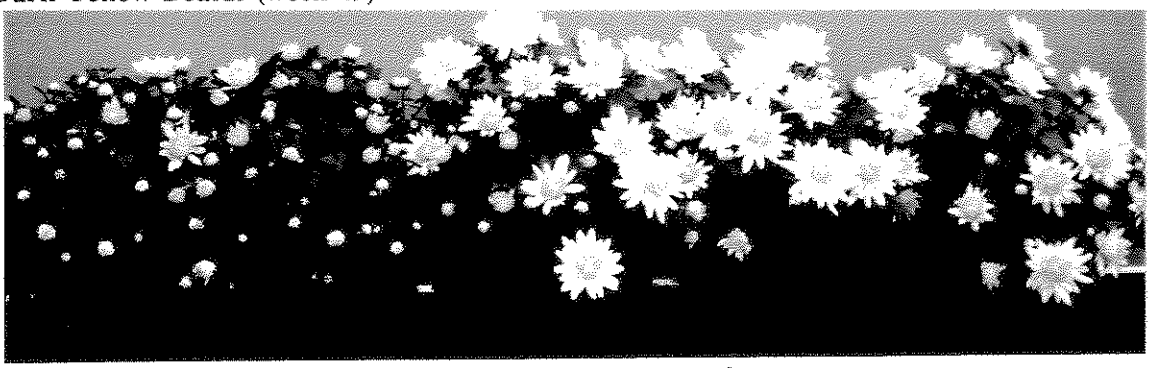
Plate 3

Main trial. Influence of supplementary lighting on winter quality

Charm (week 49)

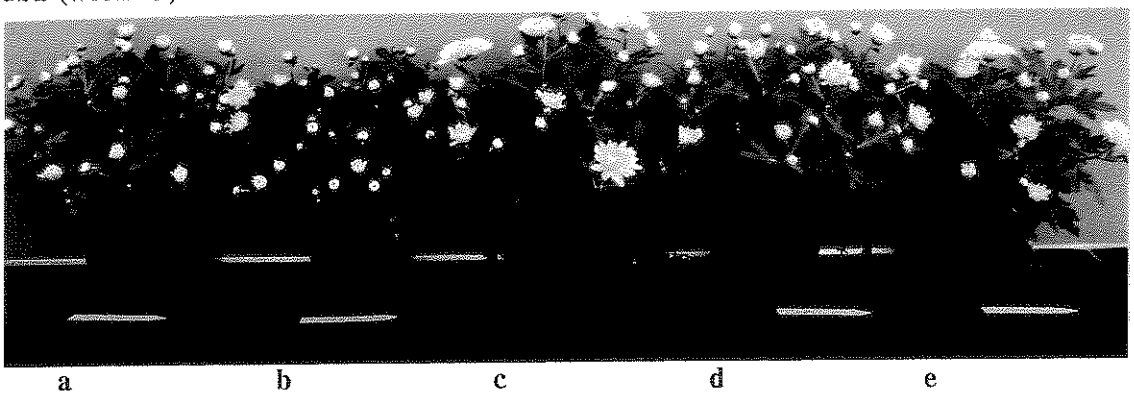
a b c d e

Dark Yellow Boaldi (week 49)



a b c d e

Yuba (week 49)



a b c d e

Lighting treatment

a	L.D. unlit	S.D. unlit
b	L.D. unlit	S.D. 2000 lux throughout
c	L.D. unlit	S.D. 5000 lux weeks 1, 2 and 3
d	L.D. lit (week 2)	S.D. 5000 lux weeks 1 and 2
e	L.D. unlit	S.D. 5000 lux weeks 1 and 2

Plate 4

Influence of stage of marketing on performance in shelf life. (Note: all photographs represent the 5000 lux supplementary lighting treatment over the first three weeks of short days)

Charm (week 45) - marketing stage 1
- week one of shelf life

Charm (week 45) - marketing stage 2
- week one of shelf life

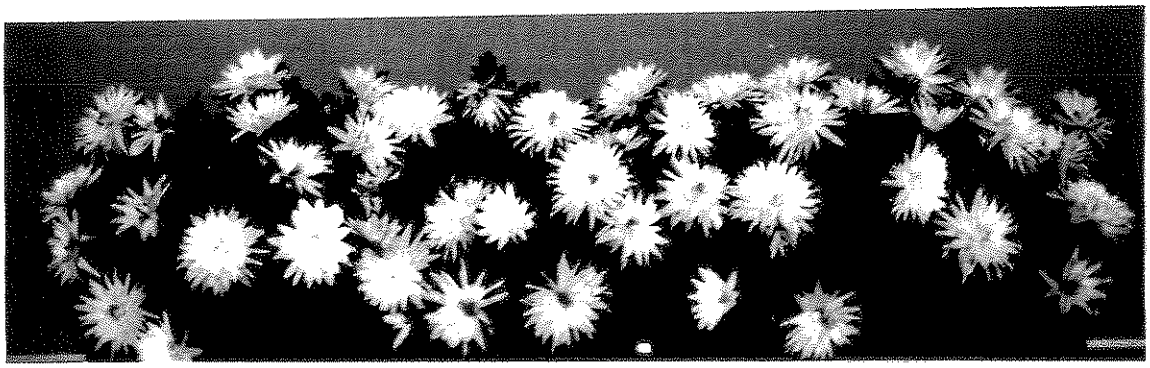
Charm (week 45) - marketing stage 3
- week one of shelf life

Plate 5

Influence of stage of marketing on performance in shelf life. (Note: all photographs represent the 5000 lux supplementary lighting treatment over the first three weeks of short days)

Charm (week 45) - marketing stage 1
- week four of shelf life

Charm (week 45) - marketing stage 2
- week four of shelf life



Charm (week 45) - marketing stage 3
- week four of shelf life

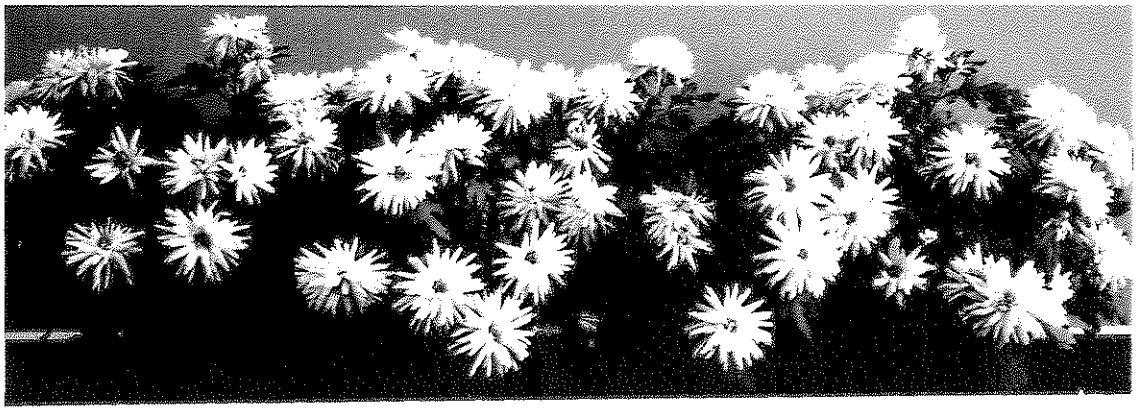


Plate 6

Influence of stage of marketing on performance in shelf life. (Note: all photographs represent the 5000 lux supplementary lighting treatment over the first three weeks of short days)

Miramar (week 45) - marketing stage 1
- week one of shelf life

Miramar (week 45) - marketing stage 2
- week one of shelf life

Miramar (week 45) - marketing stage 3
- week one of shelf life

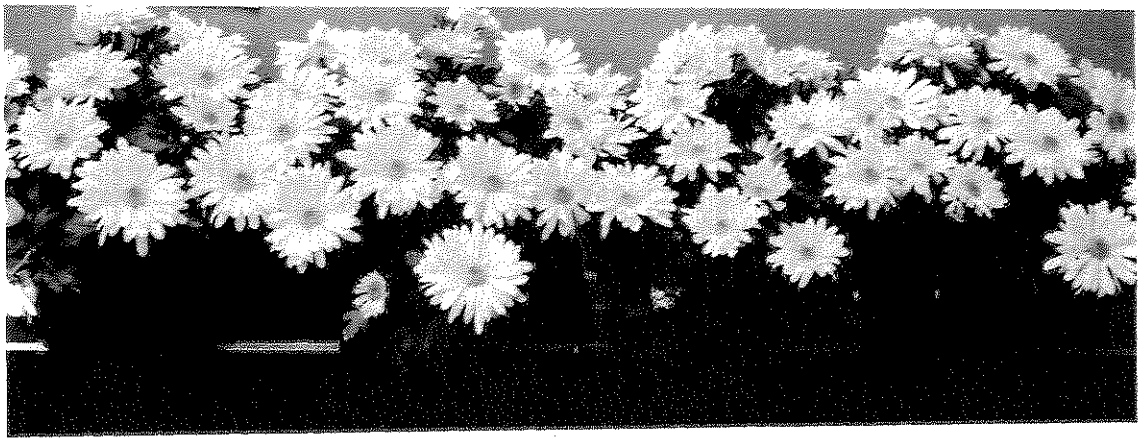


Plate 7

Influence of stage of marketing on performance in shelf life. (Note: all photographs represent the 5000 lux supplementary lighting treatment over the first three weeks of short days)

Miramar (week 45) - marketing stage 1
- week four of shelf life

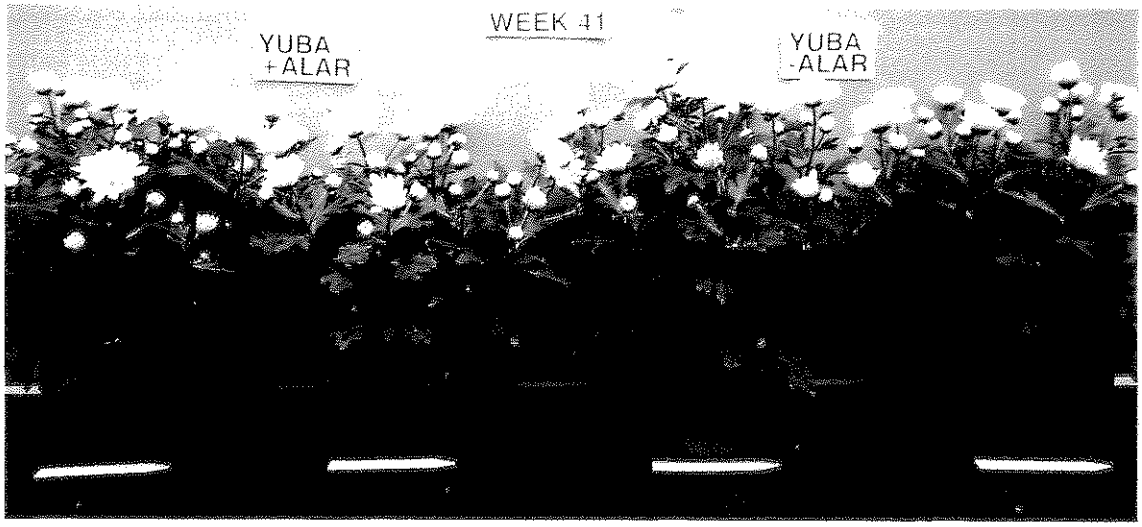
Miramar (week 45) - marketing stage 2
- week four of shelf life

Miramar (week 45) - marketing stage 3
- week four of shelf life

Plate 8

Observation trial - Combined influence of growth regulators and supplementary lighting on plant form

Yuba (week 41)



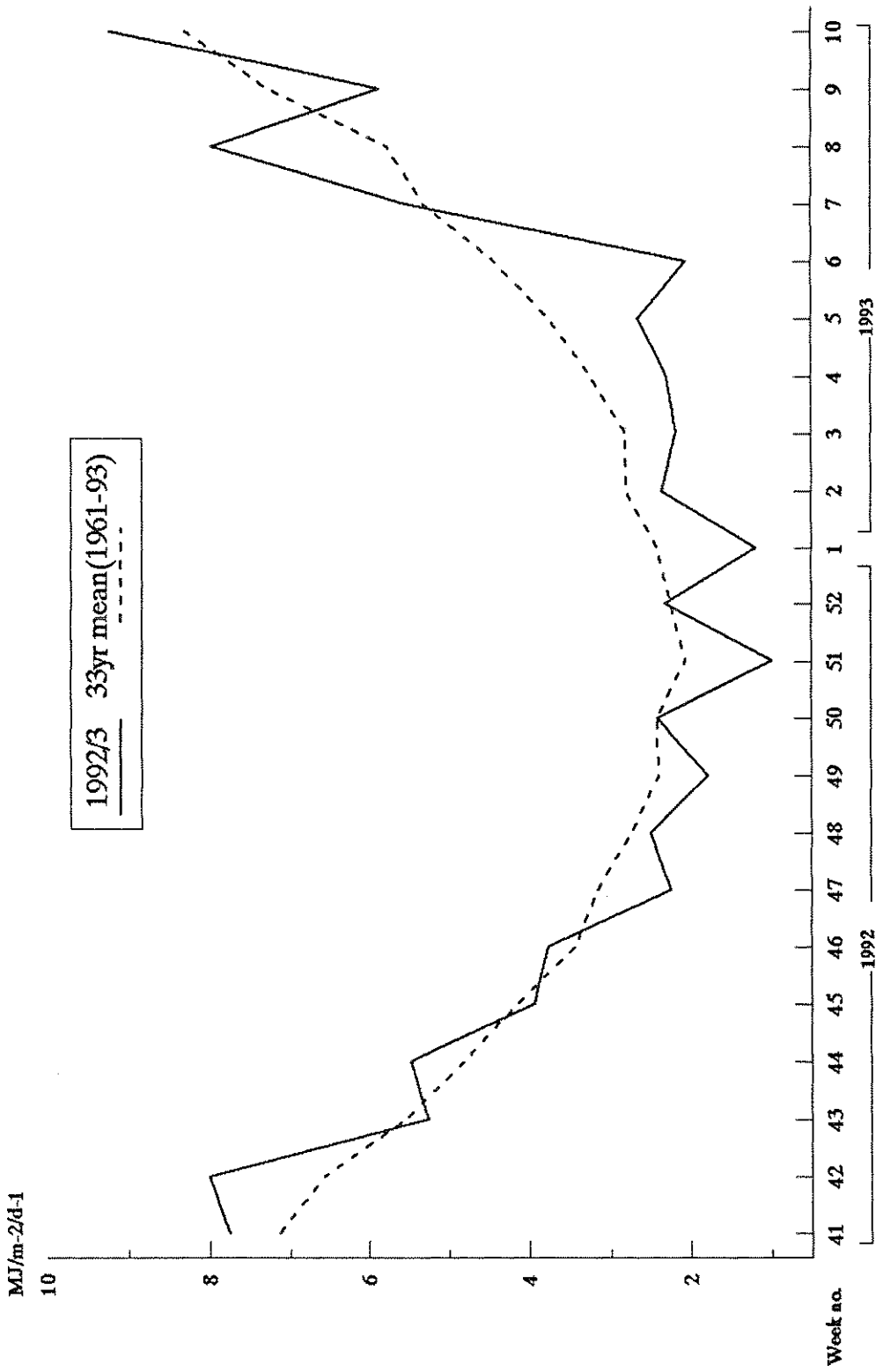
a **b** **c** **d**

Lighting treatment

a	L.D. unlit	S.D. unlit	+ Alar
b	L.D. unlit	S.D. 2000 lux throughout	+ Alar
c	L.D. unlit	S.D. unlit	- Alar
d	L.D. unlit	S.D. 2000 lux throughout	- Alar

APPENDIX X

SOLAR RADIATION DATA


1992/3
33yr mean(1961-93)
MJ/m-2/d-1
10
8
6
4
2
Week no.
41 42 43 44 45 46 47 48 49 50 51 52 1 2 3 4 5 6 7 8 9 10
1992
1993

APPENDIX XI

Copy of Contract Terms and Conditions and Schedule

APPENDIX XII

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

Finlay, A.R. 1993. Chrysanthemums: Supplementary lighting for winter production of pot chrysanthemums. Contract Report HDC PC13b

Langton, A. 1993. Control of plant stature by manipulation of day and night temperatures (DIF) regimes. Part I, Controlled environment cabinet studies. Contract Report HDC PC41

Peterson, J.C. 1982. Monitoring and managing nutrition, part IV, foliar analysis. Ohio Florists Association, Bulletin No. 632.

Sach, L. and Hand, D. 1994. Control of plant stature by manipulation of day and night temperatures (DIF) regimes. Part II, Pot Chrysanthemums. Contract Report HDC PC41