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CONTRACT REPORT

**Chrysanthemums: Supplementary lighting
for winter production of pot chrysanthemums**

**HDC PC13b
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SUMMARY

Use of supplementary lighting to improve the quality of pot chrysanthemums produced during the Short-day (S.D.) winter period has been the subject of numerous trials, initially by Hughes and Cockshull (1972) then at the Lee Valley EHS and more recently at HRI Efford. Several production schedules with relative financial benefits, have been established for Princess Anne types. The most productive schedule is the use of high intensity lighting during the first 3 weeks of short days. The trial conducted in 1991/1992, commissioned through the Horticultural Development Council (HDC), aimed to consolidate these findings (Trial 1).

Yoder bred varieties have become increasingly important in the marketplace. Hence there is a need to determine the effectiveness of 'Princess Anne type' supplementary lighting schedules for winter production of Yoder varieties. The current study examined the effect of high intensity lighting during short days on winter production of some of these varieties. In addition, the potential benefits of supplementary lighting during long days were assessed (Trial 2).

The main effects of supplementary lighting treatments were as follows:

Trial 1: Bright Golden Anne

1. Supplementary lighting at 5000 lux during the first 2 weeks of short days reduced crop time ($P < 0.001$) and an additional week of supplementary lighting reduced it further ($P < 0.001$), by up to 7 days.
2. Plants given supplementary lighting at 2000 lux throughout the short day period were shorter and more compact with darker green leaves than plants from other treatments.
3. There was no significant effect of lighting treatment on uniformity of flowering.
4. Supplementary lighting treatment had a detrimental influence on the latter stages of shelf life performance.
5. Lighting at 2000 lux throughout S.D. was the most expensive option, whereas lighting at 5000 lux for 3 or 2 weeks was progressively more cost effective.

Trial 2: Yoder varieties

1. The main treatment effect on winter production of Yoder varieties was a reduction in crop time of plants which had received supplementary lighting at 5000 lux during the first 3 weeks of short days by up to 4 days.
2. Most Yoder varieties grown under 2000 lux during the short day period were more compact than plants from other treatments, whereas those grown under 5000 lux for 3 weeks at start of short days tended to be taller than plants grown without supplementary light.
3. Greater uniformity of flowering and increased bud count was recorded in plants which received supplementary lighting (in particular those grown under 2000 lux during the short day period).
4. The influence of lighting treatments on shelf life was inconclusive, although the impact of supplementary lighting on total bud count and bud expansion was sustained.
5. Of the economic options considered, supplementary lighting at 5000 lux for the first 3 weeks of S.D. was optimal with the possible addition of 1 week supplementary lighting during long days (L.D.) to enhance total bud count.

INTRODUCTION

There are three months of the winter even in the most favoured areas of the British Isles 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 and hence the cropping time and variability of the product increases with a resultant decline in profits. Flowering uniformity, overall quality and rate of production can be improved by supplementary lighting but this needs to be considered against capital investment, running costs and optimization of space allocation.

Production schedules using supplementary lighting to improve winter quality of Princess Anne type pot chrysanthemums have been developed at the Lee Valley EHS and latterly at HRI Efford. Trial 1 (1991/92) aimed to consolidate the principal lighting schedule for winter production as high intensity lighting during the first 1-3 weeks of short days.

The effectiveness of these schedules on winter production of Yoder varieties also needs to be determined since the latter now have a larger share of the markets. The 1991/1992 study (Trial 2) examined the effect of high intensity lighting during short days on winter production of some of these varieties and assessed the potential benefits of supplementary lighting during long days.

OBJECTIVES

The objectives were:

Trial 1: To compare the effectiveness and economics of supplementary lighting of Princess Anne type pot chrysanthemums during short days with regard to quality of product, production period and shelf life.

Trial 2: To compare the effectiveness and economics of supplementary lighting schedules on Yoder varieties with regard to quality, production period and shelf life (including supplementary lighting during both the long day and short day period).

MATERIALS AND METHODS

Lighting treatments.

Trial 1 Bright Golden Anne

The following lighting treatments were applied during the short day (S.D.) period of production:

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux (12 W/m^2) during the first two weeks of short days.
- C. Supplementary lighting at 5000 lux (12 W/m^2) during the first three weeks of short days.
- D. Supplementary lighting at 2000 lux (4.8 W/m^2) throughout short days.

All plants had 2 weeks of long days (propagation) with no supplementary lighting prior to application of S.D. treatments.

Trial 2 Yoder varieties

Yoder varieties received lighting treatments during both the long day (L.D.) and the short day (S.D.) period of production.

Long days (Propagation)

- a. Unlit No supplementary lighting, 3 weeks of propagation.
- b. Lit Supplementary lighting at 5000 lux (12 W/m^2) during the second week of propagation, 2 weeks of propagation.

(Guard plants received no supplementary lighting, 2 weeks of propagation).

Short days

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux (12 W/m²) during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux (4.8 W/m²) throughout short days.

All of short day treatments were applied with or without long day lighting,

ie. aA, aB, aC, bA, bB, bC.

Supplementary lighting for both trials was given using 400 W high pressure sodium (SON/T) lamps during long days for 24 hours per day and during short days for 11 hours from 07.00 to 18.00 hrs.

Varieties

Trial 1: Bright Golden Anne

Trial 2: Yuba
Dark Yellow Boaldi
Surf
Charm
(White Diamond - limited observation)

Sticking dates

Trial 1: Week 43
Week 47

Trial 2: Week 40/41
Week 44/45
Week 48/49
(2 or 3 weeks of L.D. staggered sticking dates so that all plants started S.D. treatments concurrently)

Design

Trial 1: 4 S.D. lighting treatments
 x
 2 replicate plots
 x
 2 sticking dates
 —
 16 plots in total

Trial 2: 2 L.D. lighting treatments
 x
 3 S.D. lighting treatments
 x
 1 plot per lighting treatment
 x
 4 varieties
 x
 3 sticking dates
 —
 72 plots in total

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

Cultural details

i. Plant material

Cuttings of Bright Golden Anne were taken from from HRI Efford stock.
 Cuttings of Yoder varieties were purchased from Yoder Toddington Ltd.

ii. Propagation (Long Days)

Cuttings were potted into Fisons Levington M2 in 140 mm half pots (14D), 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 7 days. Covers were then removed and the plants weaned off. In Trial 2, polythene covers were kept in position for the first 24-48 hours after the start of the L.D. supplementary lighting treatment to facilitate more gradual weaning. 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).

[Supplementary lighting treatment during Long Days, Trial 2, is described in section - Lighting treatments.]

iii. Short Day environment

The temperature regime was set at 18°C day and night with ventilation at 21°C. Thermal screen covers were used from 18.00 to 07.00 during short days.

Enrichment with pure CO₂ 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 to leave approximately 7 leaves to regulate pot balance. Side buds were removed where appropriate (Princess Anne only). Chemical growth regulators chlorophonium chloride (Phosphon) and daminozide (Alar), were applied as appropriate according to variety and stage of development. (Appendix I, p.42).

v. Pot spacing

Pots were placed at 41 pots/m² during propagation, moved to an intermediate spacing at start of S.D. period then placed at final spacing 2-3 weeks later. (Appendix II, p.44).

vi. Nutrition

Liquid feeding at every watering commenced at the start of short days. The feed supplied N,P,K as 300 ppm N, 60 ppm P₂O₅ and 250 ppm K₂O.

vii. Pest and disease control

Protective sprays of mancozeb (Karamate Dry Flo) and deltamethrin (Decis) if appropriate were applied during propagation. A routine pest control programme, primarily for control of Western Flower Thrips was applied during the short day period. Pesticides included: aldicarb (Temik), endosulfan (Thiodan), malathion (MTM Malathion 60) and dichlorvos (Nuvan 500 EC).

Assessments

The following crop records were taken:

- i. Duration of crop, (time taken to reach marketable stage), eg. one or more flowers reaching bud stage 6. (Cockshull and Hughes, 1972).
- ii. Stage of development of most advanced flower or bud on each of the 5 plants in each pot at marketing and the number of buds/flowers per pot at stages 3, 4, 5 and above.
- iii. Height of each plant from the stem base to the tallest flower.
- iv. Maximum and minimum spread of each pot.
- v. Shelf life assessment

Time taken for plants to deteriorate from stage 1 with main flowers fully open to stages 2 and 3 (ie. partial and complete deterioration respectively) per variety and examination of treatment influence on bud expansion during shelf life.

Shelf life environment was maintained at 18-20°C and lit at 1000 lux using fluorescent lamps for 12 hours per day.

- vi. Compost analysis 5 weeks after start of short days and at marketing and leaf analysis at marketing.
- vii. Solar radiation measurements, environmental records.
- viii. Full photographic records.

Statistical analyses

Analysis of variance was carried out to determine main treatment effects. Replication of main lighting treatments was based on time (stick dates) and variety. The interaction of lighting treatment with sticking date and variety was also examined. In addition, the standard deviations of plant height and maximum bud stage per plant/pot were calculated to assess the overall pot uniformity relative to lighting treatment. (The more uniform the pot the smaller the standard deviation.)

Probability ratio 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. Trial 1. Bright Golden Anne

1.1 Effect of supplementary lighting treatment on production time

Highly significant advancement in flowering date ($P < 0.001$) was achieved in all supplementary lighting treatments, particularly, where lighting was given at 5000 lux for the first three weeks of short days, (Appendix III, Table 1, p.46). The latter was approximately 7 days ahead of plants grown under natural light conditions (average total production time 83 and 76 days respectively), while lighting at 5000 lux for the first two weeks gave a 5 day advancement in flowering. Supplementary lighting at 2000 lux throughout the short day period reduced production time by approximately 6 days.

The effects of supplementary lighting at high intensity (5000 lux) were influenced by sticking date (interaction at $P < 0.01$) such that the advancement in flowering was more marked for the later sticking date (week 47) whilst overall production time under natural light conditions was extended.

1.2 Effect of supplementary lighting treatment on plant height and pot spread

Significant reduction in plant height ($P < 0.05$) was recorded for plants grown under supplementary lighting at 2000 lux throughout the S.D. period (Appendix III, Table 2, p.47). In addition, the uniformity of plant height (5 plants) within a pot was significantly improved ($P < 0.05$) if lighting was supplied at 2000 lux throughout short days, (as indicated by reduced variation, of individual plant height from average plant height within a pot), (Appendix III, Table 3, p.48).

Pot spread was also reduced significantly ($P < 0.01$) under the lighting regime of 2000 lux throughout S.D., (Appendix III, Table 4, p.49), although the pot balance (ratio of maximum to minimum spread) was unaffected. In general, plants from the later sticking date (week 47) had a larger spread than those pots stuck earlier (week 43).

1.3 Effect of supplementary lighting treatment on flower development

Supplementary lighting treatments did not visually affect bud expansion. When assessed at marketing, the numbers of buds at stages 3 and 4 and stages 5 (and above) were comparable across all treatments (Appendix III, Table 5, p.50).

Lighting did appear to affect the total number of buds produced per pot. In general, all plants which received supplementary lighting produced significantly more buds ($P < 0.01$) than those grown under natural light conditions, (Appendix III, Table 6, p.51). This effect was influenced by sticking date i.e., for the later sticking date, plants which were lit at 5000 lux for 2 or 3 weeks produced even more buds than those lit at 2000 lux throughout S.D. ($P < 0.05$).

The average maximum bud stage per plant at marketing was stage 5, (Appendix III, Table 7, p.52).

The uniformity of flowering (as assessed by the standard deviation of maximum bud stage per plant from the average maximum bud stage per pot) was not influenced by supplementary lighting treatment, (Appendix III, Table 8, p.53), although uniformity of flowering appeared to improve under poorer natural light conditions (stick week 47) if supplementary lighting was applied at 5000 lux for 2 or 3 weeks.

1.4 Effect of supplementary lighting treatment on shelf life

No initial improvement (or deterioration) in keeping quality was recorded for plants which had received supplementary lighting treatments during the short day period i.e. the average time taken for partial deterioration was not significantly different from that of plants grown under natural light, (Appendix III, Table 9, p.54).

Once partial deterioration had occurred, those plants which had received high intensity lighting tended to deteriorate more rapidly ($P < 0.05$) than plants which had been grown under natural light conditions, i.e. those plants exposed to 5000 lux for 3 weeks had the shortest shelf life. There was however one anomaly with a relatively short shelf life of

week 43 sticking lit at 2000 lux throughout S.D. and longer shelf life of Week 47 sticking at the same light intensity.

Bud expansion continued during shelf life and almost all potential flower buds developed to stages 3 and above, (Appendix III, Table 10, p.55). As observed above, most flowers developed on plants which had received supplementary light during the S.D. period.

1.5 **Compost and leaf analyses at marketing**

Nitrate levels, although variable, were still relatively high in compost samples irrespective of supplementary lighting treatment even at the end of the crop. (Appendix III, Table 11, p.56). Highest overall nutrient levels were recorded in samples taken from plants which had been lit at 5000 lux for 3 weeks possibly because these plants required more water hence had a greater uptake of feed.

Lowest percentage dry matter was recorded in leaf samples taken from plants which had been exposed to supplementary lighting at 5000 lux for the first 2 weeks of short days. The satisfactory range of rates (ADAS) for leaf analysis: N% 2.5-6, P% 0.25-1, K% 2.5-6, Mg% 0.3-0.6 and Mn 30-300, were achieved, with P%, Mg% and Mn mg/kg - slightly in excess of these recommendations, (Appendix III, Table 12, p.57).

2. Trial 2. Yoder varieties

All experimental records for Yoder varieties are presented in Appendix IV, p.58 (Main trial), and Appendix V, p.107 (guard plants). The main responses have been summarized in this section as follows:

2.1 Effect of supplementary lighting treatment on production time

The following main effects were noted.

a. Influence of L.D. lighting treatment on production time

Number of days from sticking to marketing

Unlit	Lit
77.3	70.2

LSD (P = 0.05) = 0.30

Production time was significantly reduced (P <0.001) if plants were propagated (L.D.) for 2 weeks with lighting at 5000 lux during the second week of propagation rather than remaining for 3 weeks in L.D. without supplementary light.

b. Influence of S.D. lighting treatment on production time

Number of days from sticking to marketing

Unlit	Lit at 5000 lux first 3 weeks S.D.	Lit at 2000 lux throughout S.D.
75.2	71.6	74.4

L.S.D. (P = 0.05) = 0.37

The short day supplementary lighting treatment had a highly significant effect ($P < 0.001$) on crop duration. The main advancement in flowering was achieved by short day supplementary lighting at 5000 lux during the first three weeks of short days.

c. Influence of variety on production time

Number of days from sticking to marketing

Yuba	Dark Yellow Boaldi	Surf	Charm
75.5	74.7	72.6	72.2

L.S.D. ($P = 0.05$) = 0.42

Varietal differences in cropping time were noted ($P < 0.001$) with Charm and Surf having the fastest response time.

d. Influence of sticking date on production time

Number of days from sticking to marketing

Week 40/41	Week 44/45	Week 48/49
74.0	73.3	73.9

L.S.D. ($P = 0.05$) = 0.37

The sticking date also influenced the response time ($P < 0.01$) with fastest cropping occurring following sticking in week 44/45.

The following main factor interactions were recorded.

- e. Influence of sticking date x L.D. lighting on production time (P <0.01)

Number of days from sticking to marketing

Sticking date	Unlit	Lit
Week 40/41	78.0	70.1
Week 44/45	76.4	70.2
Week 48/49	77.4	70.3

L.S.D. (P = 0.05) = 0.52

Plants exposed to supplementary lighting during the L.D. period had similar production time irrespective of sticking date whereas those plants which had been unlit in L.D. performed best if stuck week 44/45.

- f. Influence of sticking date x S.D. lighting (P <0.001)

Number of days from sticking to marketing

Sticking date	Unlit	Lit at 5000 lux first 3 weeks S.D.	Lit at 2000 lux throughout S.D.
Week 40/41	73.3	72.5	76.2
Week 44/45	76.0	70.9	73.0
Week 48/49	76.3	71.5	73.9

L.S.D. (P = 0.05) = 0.64

Supplementary lighting at 2000 lux throughout short days extended production time by approximately 3 days beyond that of plants grown under natural light from the week 40/41

sticking whereas the converse was true for the week 44/45 and 48/49 sticking. The benefits of reduced cropping time by supply of supplementary light at 5000 lux for the first 3 weeks of S.D. was also most marked for the latter two stickings.

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

Number of days from sticking to marketing

Sticking date	Yuba	Dark Yellow Boaldi	Surf	Charm
Week 40/41	76.5	74.9	73.2	71.5
Week 44/45	74.4	75.1	71.4	72.3
Week 48/49	75.7	74.0	73.2	72.7

L.S.D. (P = 0.05) = 0.74

Although Charm had the fastest cropping time if stuck week 40/41, Surf and Yuba had the fastest production time if stuck week 44/45. Cropping time for Dark Yellow Boaldi appeared unresponsive to sticking date.

h. Influence of L.D. lighting x variety on production time (P <0.05)

Number of days from sticking to marketing

	Unlit	Lit
Yuba	79.2	71.8
Dark Yellow Boaldi	78.6	70.7
Surf	75.7	69.4
Charm	75.5	68.8

L.S.D. (P = 0.05) = 0.60

The advantages of supplementary lighting during the L.D. period were most marked for Yuba and Dark Yellow Boaldi although Surf and Charm were generally faster cropping.

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

Number of days from sticking to marketing.

Sticking date	Yuba	Dark Yellow Boaldi	Surf	Charm
Unlit				
Week 40/41	76.1	74.7	71.8	70.8
Week 44/45	76.6	77.7	74.9	74.7
Week 48/49	77.9	76.0	76.2	75.1
Lit at 5000 lux first 3 weeks S.D.				
Week 40/41	75.3	73.2	70.7	71.0
Week 44/45	72.6	72.4	68.8	69.8
Week 48/49	73.0	71.6	70.7	70.7
Lit at 2000 lux throughout S.D.				
Week 40/41	78.1	76.8	77.0	72.9
Week 44/45	74.0	75.1	70.5	72.5
Week 48/49	76.1	74.5	72.8	72.4

L.S.D. (P = 0.05) = 1.28

As natural light conditions deteriorated with later stickings, supplementary lighting treatments advanced flowering, and the second sticking of Surf and Yuba (week 44/45) seemed particularly responsive to S.D. supplementary lighting treatments.

2.2 Effect of supplementary lighting treatment on plant height

The following main effects on plant height were recorded.

- a. Influence of sticking date on plant height ($P < 0.001$).

Plant height (cm)

Week 40/41	Week 44/45	Week 48/49
22.4	22.7	20.2

L.S.D. ($P = 0.05$) = 0.31

Plants stuck in week 48/49 were shortest.

- b. Influence of L.D. lighting treatment on plant height ($P < 0.01$).

Plant height (cm)

Unlit	Lit
21.6	21.9

L.S.D. ($P = 0.05$) = 0.25

Plants supplied with supplementary lighting during the L.D. period were taller than unlit plants.

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

Plant height (cm)

Unlit	Lit at 5000 lux first 3 weeks S.D.	Lit at 2000 lux throughout S.D.
21.7	22.9	20.7

L.S.D. ($P = 0.05$) = 0.31

Supplementary lighting at 2000 lux throughout S.D. produced more compact plants than those grown under natural light whereas those supplied with 5000 lux for the first 3 weeks of S.D. were tallest.

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

Plant height (cm)

Yuba	Dark Yellow Boaldi	Surf	Charm
22.2	21.1	23.2	20.6

L.S.D. ($P = 0.05$) = 0.36

Charm and Dark Yellow Boaldi were generally shorter than Surf and Yuba.

The following variability of plant height, expressed as standard deviation of height per plant from average height was noted. (The lower the figure the more uniform the pot.)

e. Influence of sticking date on variability of plant height

Standard deviation from average per pot

Week 40/41	Week 44/45	Week 48/49
4.73	4.76	4.49

L.S.D. (P = 0.05) = 0.03

Plants stuck in week 48/49 were significantly less variable per pot (P <0.001) than those stuck in weeks 40/41 and 44/45.

f. Influence of L.D. lighting treatment on variability of plant height

Standard deviation from average per pot

Unlit	Lit
4.64	4.67

L.S.D. (P = 0.05) = 0.03

Slightly less variability per pot (P <0.05) was recorded when plants were grown under natural light conditions during the L.D. period.

g. Influence of S.D. lighting treatment on variability of plant height

Standard deviation from average per pot

Unlit	Lit at 5000 lux first 3 weeks S.D.	Lit at 2000 lux throughout S.D.
4.65	4.78	4.5

L.S.D. (P = 0.05) = 0.03

S.D. supplementary lighting at 2000 lux produced the greatest uniformity in plant height whereas those exposed to 5000 lux for the first 3 weeks of S.D. were most variable (P<0.001).

h. Influence of variety on variability of plant height

Standard deviation from average per pot

Yuba	Dark Yellow Boaldi	Surf	Charm
4.70	4.58	4.81	4.54

L.S.D. (P = 0.05) = 0.04

Charm and Dark Yellow Boaldi had greatest varietal uniformity per pot (P <0.001).

2.3 Effect of supplementary lighting treatment on pot maximum and minimum spread

The following main effects were recorded.

- a. Influence of sticking date on maximum pot spread ($P < 0.001$)

Maximum spread (cm)

Week 40/41	Week 44/45	Week 48/49
37.1	40.3	38.9

L.S.D. ($P = 0.05$) = 0.75

- b. Influence of sticking date on minimum pot spread ($P < 0.001$)

Minimum spread (cm)

Week 40/41	Week 44/45	Week 48/49
33.5	36.3	35.3

L.S.D. ($P = 0.05$) = 0.37

Largest maximum and minimum pot spread was recorded from plants stuck in weeks 44/45 (a) and (b). The ratio of maximum to minimum spread, ie. overall pot balance, was not significantly influenced by any of the main treatment factors.

- c. Influence of S.D. lighting treatment on maximum pot spread ($P < 0.05$)

Maximum spread (cm)

Unlit	Lit at 5000 lux first 3 weeks S.D.	Lit at 2000 lux throughout S.D.
39.5	38.4	38.5

L.S.D. ($P = 0.05$) = 0.75

- d. Influence of S.D. lighting treatment on minimum pot spread ($P < 0.001$)

Minimum spread (cm)

Unlit	Lit at 5000 lux first 3 weeks S.D.	Lit at 2000 lux throughout S.D.
35.7	34.7	34.6

L.S.D. ($P = 0.05$) = 0.37

Plants which received supplementary lighting during S.D. were more compact than those which had been grown under natural light conditions (c) and (d).

- e. Influence of variety on maximum pot spread ($P < 0.001$)

Maximum spread (cm)

Yuba	Dark Yellow Boaldi	Surf	Charm
37.9	40.7	39.7	36.8

L.S.D. ($P = 0.05$) = 0.87

f. Influence of variety on minimum pot spread ($P < 0.001$)

Minimum spread (cm)

Yuba	Dark Yellow Boaldi	Surf	Charm
34.4	36.7	35.8	33.1

L.S.D. ($P = 0.05$) = 0.43

Charm and Yuba were the most compact varieties (e) and (f).

2.4 Effect of supplementary lighting treatment on flower development

2.4.1 Bud expansion - Number at stages 3 and 4 per pot.

The number of buds, at stages 3 and 4 recorded at marketing, was significantly influenced by sticking date, L.D. lighting, S.D. lighting and variety ($P < 0.001$, $P < 0.05$, $P < 0.001$ and $P < 0.001$ respectively).

a. Influence of sticking date on flower development (bud expansion)

Number of buds at stages 3 and 4 per pot

Week 40/41	Week 44/45	Week 48/49
29.3	34.2	31.0

L.S.D. ($P = 0.05$) = 1.64

In particular, plants stuck week 44/45 had the greater number of buds at stages 3 and 4.

b. Influence of L.D. lighting treatment on flower development (bud expansion)

Number of buds at stages 3 and 4 per pot.

Unlit	Lit
30.6	32.4

L.S.D. ($P = 0.05$) = 1.34

Plants which had been given L.D. supplementary lighting also had the greater number of buds at stages 3 and 4.

c. Influence of S.D. lighting treatment on flower development (bud expansion)

Number of buds at stages 3 and 4 per pot.

Unlit	Lit at 5000 lux first 3 weeks S.D.	Lit at 2000 lux throughout S.D.
27.7	31.2	35.6

L.S.D. (P = 0.05) = 1.64

Supplementary lighting at 2000 lux throughout short days gave a marked increase in number of buds at stages 3 and 4, with approximately 8 more buds per plant than 'unlit' plants.

d. Influence of variety on flower development (bud expansion)

Number of buds at stages 3 and 4 per pot

Yuba	Dark Yellow Boaldi	Surf	Charm
35.7	34.6	27.0	28.6

L.S.D. (P = 0.05) = 1.89

At marketing, Yuba and Dark Yellow Boaldi had more buds at stages 3 and 4 than Surf and Charm.

The number of buds at stages 5 and above, recorded at marketing was also significantly influenced by sticking date, L.D. lighting, S.D. lighting and variety (P<0.001, P<0.01, P<0.05 and P<0.01 respectively). Bud expansion in particular was promoted by both L.D. and S.D. supplementary lighting.

2.4.2 Total number of buds and flowers

e. Influence of sticking date on total number of flowers produced

Total number of buds and flowers

Week 40/41	Week 44/45	Week 48/49
50.6	51.5	63.0

L.S.D. (P = 0.05) = 1.74

The total number of buds produced per pot was influenced by sticking date (P<0.001), and most buds were produced on plants stuck week 48/49.

f. Influence of L.D. lighting treatment on total number of flowers produced

Total number of buds and flowers.

Unlit	Lit
53.7	56.3

L.S.D. (P = 0.05) = 1.42

- g. Influence of S.D. lighting treatment on total number of flowers produced.

Total number of buds and flowers.

Unlit	Lit at 5000 lux first 3 weeks S.D.	Lit at 2000 lux throughout S.D.
49.0	53.4	62.7

L.S.D. (P = 0.05) = 1.74

Supplementary lighting during both the L.D. (f) and S.D. period (g), enhanced bud production (P<0.001, P<0.001 respectively) with approximately 13 more buds per pot recorded on plants which had received supplementary lighting at 2000 lux throughout the S.D. period than on unlit plants.

- h. Influence of variety on total number of flowers produced

Total number of buds and flowers.

Yuba	Dark Yellow Boaldi	Surf	Charm
59.6	56.8	50.0	53.6

L.S.D. (P = 0.05) = 2.01

Total bud count was greatest for Yuba.

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

The average maximum bud stage per plant at marketing was stage 5. The uniformity of flowering (as assessed by the standard deviation of maximum bud stage per plant from the average maximum bud stage per pot) was influenced by sticking date, L.D. and S.D.

supplementary lighting and variety ($P < 0.001$, $P < 0.05$, $P < 0.01$ and $P < 0.01$ respectively).
 (The smaller the standard deviation the greater the uniformity).

i. Influence of sticking date on uniformity of flowering

Standard deviation of maximum bud stage.

Week 40/41	Week 44/45	Week 48/49
0.80	0.94	0.96

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

Greater uniformity was achieved by sticking earlier (week 40/41)

j. Influence of L.D. lighting treatment on uniformity of flowering

Standard deviation of maximum bud stage.

Unlit	Lit
0.94	0.87

L.S.D. ($P = 0.05$) = 0.06

k. Influence of S.D. lighting treatment on uniformity of flowering

Standard deviation of maximum bud stage.

Unlit	Lit at 5000 lux first 3 weeks S.D.	Lit at 2000 lux throughout S.D.
0.98	0.88	0.85

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

Both L.D. and S.D. supplementary lighting improved uniformity of flowering (j) and (k).

l. Influence of variety on uniformity of flowering

Standard deviation of maximum bud stage.

Yuba	Dark Yellow Boaldi	Surf	Charm
0.85	0.98	0.95	0.83

L.S.D. (P = 0.05) = 0.08

Charm and Yuba exhibited greater uniformity of flowering than Dark Yellow Boaldi and Surf.

Detail of actual values recorded for each variety per sticking date and L.D. and S.D. lighting treatment are shown in Appendix IV, p.58.

2.5 Effect of supplementary lighting treatment on shelf life

S.D. supplementary lighting treatment, sticking date and variety all influenced the shelf life properties of the Yoder varieties tested (all $P < 0.001$, shelf life stage 1 to stage 2).

2.5.1 Number of days taken to deteriorate from stage 1 to stages 2 and 3.

a. Influence of sticking date on shelf life

Number of days taken to deteriorate from stage 1 to stages 2 and 3.

	Week 40/41	Week 44/45	Week 48/49	
Stage 1→2	10.7	7.5	11.8	L.S.D.(P = 0.05) = 0.61
Stage 2→3	9.0	11.4	11.2	L.S.D.(P = 0.05) = 1.22
(Total)	(19.7)	(18.9)	(23.0)	

Plants stuck in weeks 44/45 had a shorter initial shelf life than those stuck weeks 40/41 and weeks 48/49.

b. Influence of S.D. lighting treatment on shelf life

Number of days taken to deteriorate from stage 1 to stages 2 and 3.

	Unlit	Lit at 5000 lux first 3 weeks S.D.	Lit at 2000 lux throughout S.D.	
Stage 1→2	9.2	10.9	9.9	L.S.D.(P = 0.05) = 0.61
Stage 2→3	9.8	10.6	11.2	L.S.D. = N.S.
(Total)	(19.0)	(21.5)	(21.1)	

Plants grown under natural light conditions deteriorated more rapidly from stage 1 to stage 2 than those supplied with S.D. supplementary lighting.

c. Influence of variety on shelf life

Number of days taken to deteriorate from stage 1 to stages 2 and 3.

	Yuba	Dark Yellow Boaldi	Surf	Charm	
Stage 1→2	10.3	8.9	11.0	9.7	L.S.D.(P = 0.05) = 0.70
Stage 2→3	9.5	10.2	11.7	10.7	L.S.D. = N.S.
(Total)	(19.8)	(19.1)	(22.7)	(20.4)	

Surf had the best keeping quality of the varieties tested.

2.5.2 Influence of lighting treatment on bud expansion during shelf life

a. Influence of sticking date on bud expansion during shelf life

Number of flowers at stage 3, 4, 5 and above and total number of buds per pot.

Stages	Week 40/41	Week 44/45	Week 48/49	P.	L.S.D.(P=0.05)
3, 4	7.3	12.8	13.0	<0.001	1.40
5, 5+	33.6	30.0	36.8	<0.001	1.76
Total	57.3	50.9	62.9	<0.001	1.14

As noted earlier, more buds were produced on plants stuck later (weeks 48/49) and this expansion was sustained through shelf life.

b. Influence of L.D. lighting on bud expansion during shelf life

Number of flowers at stages 3, 4, 5 and above and total number of buds per pot.

Stage	Unlit	Lit	P.	L.S.D. (P = 0.05)
3, 4	10.9	11.2	N.S.	-
5, 5+	32.4	34.5	<0.05	1.43
Total	55.8	58.3	<0.001	0.93

Supplementary lighting during L.D. enhanced total bud production and was reflected in shelf life assessment.

c. Influence of S.D. lighting on bud expansion

Number of flowers at stages 3, 4, 5 and above and total number of buds per pot.

Stage	Unlit	Lit at 5000 lux first 3 weeks S.D.	Lit at 2000 lux throughout S.D.	P.	L.S.D. (P=0.05)
3, 4	10.0	7.7	15.4	<0.001	1.40
5, 5+	29.2	34.6	36.6	<0.001	1.76
Total	51.3	54.8	65.0	<0.001	1.14

Supplementary lighting during S.D., especially at 2000 lux for the entire production period, gave a sustained increase in bud production and expansion continued during shelf life.

d. Influence of variety on bud expansion during shelf life

Number of flowers at stages 3, 4, 5 and above and total number of buds per pot.

Stage	Yuba	Dark Yellow Boaldi	Surf	Charm	P.	L.S.D. (P=0.05)
3, 4	14.3	10.5	8.6	10.8	<0.001	1.62
5, 5+	33.4	37.0	33.6	29.8	<0.001	2.03
Total	60.8	58.6	52.9	55.8	<0.001	1.32

Yuba had the greatest number of flowers recorded as already indicated by the main trial record.

2.6 Compost and leaf analysis at marketing

Details of compost analyses from Trial 2 are given in Appendix IV, p.58. No distinct trends in analyses relative to treatment conditions were noted.

Lowest percentage leaf dry matter tended to be associated with plants which had been grown under natural light conditions. Satisfactory levels of %N and Total K% were achieved. Total P%, Total Mg% and Total Mn mg/kg were slightly in excess of the ADAS recommended range.

3. Economic evaluations. (Trial 1 and Trial 2).

An economic evaluation of treatments is presented in Appendix VI, p.121.

4. Photographic records. (Trial 1 and Trial 2).

Main treatment effects are displayed in Appendix VII, p.131.

5. Solar radiation

Details of solar radiation during the trial period are shown in Appendix VIII, p.144.

DISCUSSION

Trial 1. Bright Golden Anne

Supplementary lighting of Bright Golden Anne with high intensity sodium lamps SON/T produced very favourable results during the trial period with advancement in flowering by up to 7 days if light was supplied at 5000 lux for the first 3 weeks of short days (consolidating results from previous trials at Lee Valley EHS and Efford). However the advancement in flowering may not be offset by the cost of this treatment (13.2 p/pot) and the reduced option of 5000 lux for the first 2 weeks (8.9 p/pot) with approximate advancement in flowering by 5 days may be the preferred option.

Overall improvement in uniformity of plant height and pot spread was noted for plants which had been supplied with 2000 lux throughout S.D. but since this treatment was the most expensive option (22.1 p/pot) an enhanced premium based on improved quality may be required to offset the increased costs. The additional benefit of this treatment ie. improved plant 'compactness' may prove useful if non-chemical methods of height control become necessary. (The physiological explanation of this phenomenon was based on the spectral balance of light supplied to the plants and the latter may merit further study).

Since a higher overall bud count was recorded on plants which had received supplementary lighting (at 5000 lux and 2000 lux) during S.D. this may also merit an enhanced quality premium.

Although supplementary lighting at 5000 lux for the first 3 weeks of S.D. gave the most favourable overall production response it produced the least satisfactory shelf life results. This factor needs to be taken into consideration when determining how best to meet and sustain market requirements.

It remains for growers to examine the merits of these treatments relative to their individual growing systems and market demands to determine the best option to meet those requirements.

Trial 2. Yoder varieties

Yoder varieties responded well to 'Anne type' lighting schedules with an overall advancement in flowering of approximately 4 days following lighting at 5000 lux for the first 3 weeks of S.D.

There was a marked advantage of reduced production time by using a 2 week L.D. schedule with lighting during the second week rather than propagating for 3 weeks without lighting, with minimal additional cost. Observations which were carried out on plants which received 2 weeks L.D. schedule without light indicated that L.D. lighting may not enhance response time. However, L.D. lighting did enhance total bud count per pot. The benefits of lighting during L.D. will be further examined in the 92/93 study.

Since 'Yuba' and 'Dark Yellow Boaldi' appeared more responsive to L.D. lighting than 'Surf' and 'Charm' it may be appropriate to tailor resources to match varietal response i.e. if lighting resource is limited it may be most profitably be used on responsive varieties.

As with 'Annes' the 2000 lux lighting supplied during S.D. resulted in more compact plants with less variability in plant height per pot whereas lighting at 5000 lux for the first 3 weeks of S.D. resulted in taller plants with slightly increased variability. The latter results need to be balanced with the flowering response time (i.e. faster at 5000 lux) in order to determine which factor has the greatest effect on profitability. Supplementary lighting at 2000 lux during S.D. generally improved compactness of pot spread and an overall enhancement in plant leaf colour was noted. This general improvement in plant form and colour may merit a market premium.

In addition, both L.D. and S.D. supplementary lighting improved flower development both in terms of total bud count and overall uniformity of bud development and expansion with no marked shelf life deterioration following lighting treatment. Although L.D. lighting only slightly increased the overall cost of the lighting treatments the cost of S.D. lighting, at 2000 lux throughout was almost double that of S.D. lighting at 5000 lux for the first 3 weeks of S.D.

In conclusion it is noted that high intensity supplementary lighting during the early part of the S.D. period may prove the most useful tool in manipulating winter quality of pot chrysanthemums, with possible additional effects of supplementary lighting as supplied during L.D.

In order to determine the perceived economic benefits of such treatments it is necessary for growers to evaluate their own returns based on ie. spacing, lighting rig position/mobility, throughput of crops, potential quality premium etc.

CONCLUSIONS

This study successfully confirmed the results of previous trials which established high intensity supplementary lighting during the first 3 weeks of short days as the most effective lighting schedule for winter production of Princess Anne type pot chrysanthemums.

- Supplementary lighting at 5000 lux for 3 weeks at the start of short days reduced production time by up to 7 days.
- Supplementary lighting at 2000 lux influenced plant form such that these plants were shorter and more compact than plants from other treatments.
- Lighting at 2000 lux throughout S.D. was the most expensive option, whereas lighting at 5000 lux for 3 or 2 weeks was progressively more cost effective.

The 'Anne' type supplementary lighting schedules were also successfully applied to Yoder varieties.

- Supplementary lighting at 5000 lux during the first 3 weeks of short days reduced production schedules of these varieties by up to 4 days, greater uniformity of flowering and increased bud count were recorded for these plants.
- As with the 'Anne's', Yoder varieties grown under 2000 lux during the short day period were more compact than plants from other treatments, whereas those grown under 5000 lux for 3 weeks at start of short days tended to be taller than plants grown without supplementary light.
- Of the economic options considered, supplementary lighting at 5000 lux for the first 3 weeks of short days was optimal with the possible addition of 1 week supplementary lighting during long days to enhance total bud count.

RECOMMENDATIONS FOR FURTHER WORK

Improved production of decorative types of Yoder bred varieties during the winter period is possible if supplementary lighting is supplied and needs to be further evaluated. In addition, the market may be extended if single type Yoder bred varieties could be successfully grown during the winter. This may only be achieved if these varieties respond positively to supplementary lighting during winter and under comparable conditions to those used for production of decorative types.

Varietal response to supplementary lighting regimes, and the stage at which the product is marketed, may also 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 of Yoder bred varieties may be achieved if marketing takes place at a later stage. It is important therefore to determine the influence of such production techniques on end product performance in order to ensure popularity in the market place.

Hence there is need to:

- a. Evaluate the potential benefits of supplementary lighting for winter production on a range of Yoder bred single and decorative varieties.
- b. Examine the influence of these lighting regimes on shelf life qualities.
- c. Assess the influence of stage of marketing on plant performance under shelf life conditions.
- d. 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.

APPENDIX I.

Use of growth regulants - rates of application

Trial 1. Bright Golden Anne

1. Phosfon 0.4 g/l

2. Alar
 - a. 1.25 g/l (1000 ppm) applied 24 hrs after sheet removal during propagation only if there are signs of stretching.
 - b. 2.5 g/l (2000 ppm) applied 7 days after pinching.
 - c. 2.5 g/l (2000 ppm) applied 14 days after pinching.
 - d. 2.5 g/l (2000 ppm) applied 21-25 days after pinching only if breaks are stretching.

b. and c. applied routinely, a. and d. applied if necessary.

Trial 2. Yoder varieties

Variety	Alar* application rate		
	Phosfon (g/l)	g/l	ppm
Yuba	Nil	1.5	1250
Dark Yellow Boaldi	0.2	1.5	1250
Surf	Nil	Nil or 1.5	1250
Charm	0.2	2.4 + 1.5 as required later	2000 + 1250
White Diamond	0.2	1.5	1250

* Alar applied when breaks were 3/4" to 1" long.

Use of growth regulants - dates of application

Trial 1. Bright Golden Anne

- a. Phosphon at 0.4 g/l in compost.
- b. Alar application.

Stick date	Week 43 23.10.91	Week 47 20.11.91
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Alar application rate

1.25 g/l - at start of S.D.	7.11.91	5.12.91
2.5 g/l - 14 days after pinching	26.11.91	28.12.91
2.5 g/l - 21-25 days after pinching	5.12.91	18. 1.91

Trial 2. Yoder varieties

- a. Phosphon at 0.2 g/l in compost. Dark Yellow Boaldi, Charm and White Diamond only.
- b. Alar application

Stick date	Week 40/41 2.10.91/9.10.91	Week 44/45 30.10.91/6.11.91	Week 48/49 26.11.91/4.12.91
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Alar application rate

First application

2.4 g/l - Charm	8.11.91, 11.11.91	5.12.91	9.1.92
1.5 g/l - All other varieties	14.11.91	5.12.91	9.1.92

Second application

1.5 g/l - Charm	26.11.91	-	21.1.92
1.25 g/l - All other varieties	-	-	21.1.92

APPENDIX II.**Pot spacing**

Trial 1. Bright Golden Anne

Period (cm)	Duration	Pots/m ²	Pot Spacing
Long days	41	15.62 x 15.62	2 weeks
Short days - intermediate	16	25.0 x 25.0	3 weeks
Short days - final	11.5	29.5 x 29.5	To flower

Trial 2. Yoder varieties

Period (cm)	Duration	Pots/m ²	Pot Spacing
Long days	41	15.62 x 15.62	2-3 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.

Trial 1. Bright Golden Anne. Tables of results.

APPENDIX III.**Table 1. Effect of lighting treatment on production time of Bright Golden Anne**

Stick date	Number of days from sticking to marketing				(Mean)
	A	B	C	D	
Week 43	81.9 ^a	78.8	76.4	75.2	(78.1)
Week 47	84.4 ^a	77.3	75.6	79.4	(79.1)
(Mean)	(83.1)	(78.1)	(76.0)	(77.3)	

Lighting treatment

- A. No supplementary light.
- B. Supplementary light at 5000 lux during weeks 1-2 of short days.
- C. Supplementary light at 5000 lux during weeks 1-3 of short days.
- D. Supplementary light at 2000 lux throughout short days.

^a = Mean of 20 replicate pots per treatment per stick date

Significance of treatment influence

	Production time	L.S.D.
Stick date	*	0.75
Lighting treatment	***	1.11
Stick date/Lighting treatment	**	1.62

Probability ratio P = * P <0.05, ** P<0.01, *** P<0.001

N.S. Non significant

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

APPENDIX III.**Table 2. Effect of lighting treatment on plant height of Bright Golden Anne**

Stick date	Plant height (cm) relative to lighting treatment			
	A	B	C	D
Week 43	17.7 ^a	17.5	17.4	16.1
Week 47	17.1	16.4	17.3	15.6
(Mean)	(17.4)	(16.9)	(17.3)	(15.8)

Lighting treatment

- A. No supplementary light.
- B. Supplementary light at 5 lux during weeks 1-2 of short days.
- C. Supplementary light at 5 lux during weeks 1-3 of short days.
- D. Supplementary light at 2 lux throughout short days.

^a = Mean plant height 5 plants per pot, 20 pots per treatment per stick date.

Significance of treatment influence

	Plant height	L.S.D.
Stick date	N.S.	-
Lighting treatment	*	0.91
Stick date/Lighting treatment	N.S.	-

APPENDIX III.

Table 3. Effect of lighting treatment on uniformity of plant height per pot (assessed as standard deviation of plant height)

Stick date	Standard deviation from average of plant height per plant per pot relative to lighting treatment			
	A	B	C	D
Week 43	4.20 ^a	4.18	4.16	4.01
Week 47	4.13	4.05	4.15	3.94
(Mean)	(4.17)	(4.11)	(4.16)	(3.98)

Lighting treatment

- A. No supplementary light.
- B. Supplementary light at 5000 lux during weeks 1-2 of short days.
- C. Supplementary light at 5000 lux during weeks 1-3 of short days.
- D. Supplementary light at 2000 lux throughout short days.

^a = Standard deviation from average of plant height of 5 plants per pot, 20 replicate pots per treatment per stick date.

Significance of treatment influence

	Standard deviation of plant height	L.S.D.
Stick date	N.S.	-
Lighting treatment	*	0.11
Stick date/Lighting treatment	N.S.	-

APPENDIX III.

Table 4. Effect of lighting treatment on pot spread of Bright Golden Anne

Stick date	Spread	Response to lighting treatment (spread - cm)			
		A	B	C	D
Week 43	Maximum	38.3 ^a	37.7	37.8	34.2
	Minimum	34.1 ^a	32.7	33.7	30.8
	Ratio	1.13	1.16	1.13	1.12
Week 47	Maximum	40.9	39.1	39.3	39.2
	Minimum	37.2	35.3	35.3	35.3
	Ratio	1.10	1.11	1.11	1.11
Mean	Maximum	39.6	38.4	38.5	36.7
	Minimum	35.7	34.0	34.5	33.1

Lighting treatment

- A. No supplementary light
- B. Supplementary light at 5000 lux during weeks 1-2 of short days.
- C. Supplementary light at 5000 lux during weeks 1-3 of short days.
- D. Supplementary light at 2000 lux throughout short days.

^a = Mean of 20 replicate pots per treatment per stick date

Significance of treatment influence

	Maximum Spread	L.S.D.	Minimum Spread	L.S.D.	Ratio	L.S.D.
Stick date	***	0.78	***	0.76	NS	-
Lighting treatment	**	1.13	**	1.11	NS	-
Stick date/ Lighting treatment	*	1.66	NS	-	NS	-

APPENDIX III.

Table 5. Effect of lighting treatment on bud development of Bright Golden Anne assessed at marketing stage.

Stick date	Bud ^a stage	Average number of buds at stages 3, 4, 5 and greater than 5 per pot relative to lighting treatments			
		A	B	C	D
Week 43	3, 4	5.7 ^b	5.7	5.4	5.9
	5, 5+	4.2	3.2	3.6	4.5
Week 47	3, 4	6.1	7.4	6.0	7.1
	5, 5+	4.3	4.2	6.3	4.6

Lighting treatment

- A. No supplementary light.
- B. Supplementary light at 5000 lux during weeks 1-2 of short days.
- C. Supplementary light at 5000 lux during weeks 1-3 of short days.
- D. Supplementary light at 2000 lux throughout short days.

^a = Bud stages as defined by Cockshull and Hughes (1972)

^b = Mean number of buds, 5 plants per pot, 20 replicate pots per treatment per stick date.

Significance of treatment influence

	Bud stages 3, 4	L.S.D	Bud stages 5, 5+	L.S.D.
Stick date	*	0.49	**	0.61
Lighting treatment	N.S.	-	N.S.	-
Stick date/Lighting treatment	N.S.	-	*	1.29

APPENDIX III.

Table 6. Effect of lighting treatment on total bud count (stage 1 and above) of Bright Golden Anne assessed at marketing.

Stick date	Total bud count per pot relative to lighting treatment				(Mean)
	A	B	C	D	
Week 43	13.6 ^a	14.2	13.7	14.8	(14.0)
Week 47	13.4	14.9	15.2	14.5	(14.5)
(Mean)	(13.5)	(14.5)	(14.4)	(14.6)	

Lighting treatment

- A. No supplementary light
- B. Supplementary light at 5000 lux during weeks 1-2 of short days.
- C. Supplementary light at 5000 lux during weeks 1-3 of short days.
- D. Supplementary light at 2000 lux throughout short days.

^a = Mean of 20 replicate pots per treatment per stick date.

Significance of treatment influence

	Total bud count	L.S.D.
Stick date	*	0.30
Lighting treatment	**	0.45
Stick date/Lighting treatment	*	0.65

APPENDIX III.

Table 7. Effect of lighting treatment on uniformity of flowering (average maximum bud stage per plant) of Bright Golden Anne assessed at marketing.

Stick date	Average maximum bud stage per plant relative to lighting treatment			
	A	B	C	D
Week 43	4.7 ^a	4.4	4.5	5.0
Week 47	4.5	4.8	5.0	4.7

Lighting treatment

- A. No supplementary light.
- B. Supplementary light at 5000 lux during weeks 1-2 of short days.
- C. Supplementary light at 5000 lux during weeks 1-3 of short days.
- D. Supplementary light at 2000 lux throughout short days.

^a = Mean of 5 plants per pot, 20 replicate pots per treatment per stick date.

Significance of treatment influence

	Average bud stage	L.S.D.
Stick date	N.S.	-
Lighting treatment	N.S.	-
Stick date/Lighting treatment	*	0.42

APPENDIX III.

Table 8. Effect of lighting treatment on uniformity of flowering per pot (assessed as standard deviation of maximum bud stage per plant) of Bright Golden Anne

Stick date	Standard deviation from average of maximum bud stage per plant per pot relative to lighting treatment			
	A	B	C	D
Week 43	1.17 ^a	1.33	1.21	0.90
Week 47	1.20	1.17	0.96	1.28

Lighting treatment

- A. No supplementary light.
- B. Supplementary light at 5000 lux during weeks 1-2 of short days.
- C. Supplementary light at 5000 lux during weeks 1-3 of short days.
- D. Supplementary light at 2000 lux throughout short days.

^a = Standard deviation from average of maximum bud stage of 5 plants per pot, 20 replicate pots per treatment per stick date.

Significance of treatment influence

	Standard deviation of max. bud stage	L.S.D.
Stick date	N.S.	-
Lighting treatment	N.S.	-
Stick date/Lighting treatment	*	0.22

APPENDIX III.

Table 9. Effect of lighting treatment on shelf-life of Bright Golden Anne

Stick date	Shelf life stage	Number of days taken to deteriorate from shelf life stage 1 to stage 2 and stage 2 to stage 3			
		A	B	C	D
Week 43	1→2	5.2 ^a	6.3	6.1	7.0
	2→3	15.9	14.3	10.6	5.5
	(Total)	(21.1)	(20.6)	(16.7)	(12.5)
Week 47	1→2	7.5	5.0	5.2	6.5
	2→3	16.5	12.3	9.7	19.2
	(Total)	(24.0)	(17.3)	(14.9)	(25.7)

Lighting treatment

- A. No supplementary light.
- B. Supplementary light at 5000 lux during weeks 1-2 of short days.
- C. Supplementary light at 5000 lux during weeks 1-3 of short days.
- D. Supplementary light at 2000 lux throughout short days.

Shelf life stage 1 = marketable
 2 = slightly deteriorated
 3 = completely deteriorated

^a = Mean of 10 replicate pots per treatment per stick date.

Significance of treatment influence

	No. of days to deteriorate		L.S.D.	
	1→2	2→3	1→2	2→3
Stick date	N.S.	*	-	1.8
Lighting treatment	N.S.	*	-	2.7
Stick date/Lighting treatment	*	**	1.8	4.1

APPENDIX III.

Table 10. Effect of lighting treatment on subsequent bud expansion during shelf life of Bright Golden Anne (assessed at shelf life stage 2).

Stick date	Bud stage	Number of buds at stages 3, 4, 5 and above at shelf life stage 2 relative to lighting treatment			
		A	B	C	D
Week 43	3, 4	2.2 ^a	1.8	2.2	1.7
	5, 5+	10.1	10.1	10.6	11.8
	Total	13.2	13.5	13.7	13.7
Week 47	3, 4	1.6	2.5	1.8	2.1
	5, 5+	11.4	11.5	11.9	12.0
	Total	13.2	14.8	15.4	14.6

Lighting treatment

- A. No supplementary light.
- B. Supplementary light at 5000 lux during weeks 1-2 of short days.
- C. Supplementary light at 5000 lux during weeks 1-3 of short days.
- D. Supplementary light at 2000 lux throughout short days.

^a = Mean of 10 replicate pots per treatment per stick date.

Significance of treatment influence

	3, 4	L.S.D.	5, 5+	L.S.D.	Total	L.S.D.
Stick date	N.S.	-	**	0.6	**	0.54
Lighting treatment	N.S.	-	N.S.	-	**	0.79
Stick date/ Lighting treatment	N.S.	-	N.S.	-	N.S.	-

APPENDIX III.

Table 11. Compost analyses at marketing of Bright Golden Anne (relative to lighting treatment).

Stick date	Lighting treatment	Compost analyses						
		pH	P mg/l	K mg/l	Mg mg/l	Cond μ S	NO ₃ -N mg/l	NH ₄ N mg/l
Week 43	A	5.4	11	34	28	119	39	<1
Week 47		5.9	1	3	13	63	6	<1
Week 43	B	5.5	9	17	32	119	28	<1
Week 47		5.5	7	13	31	116	33	1
Week 43	C	5.3	15	46	33	144	59	1
Week 47		5.4	10	23	44	168	67	<1
Week 43	D	5.7	21	15	63	185	16	<1
Week 47		5.3	4	6	61	191	59	0.5

Lighting treatment

- A. No supplementary light
- B. Supplementary light at 5000 lux during weeks 1-2 of short days.
- C. Supplementary light at 5000 lux during weeks 1-3 of short days.
- D. Supplementary light at 2000 lux throughout short days.

APPENDIX III.

Table 12. Leaf analyses at marketing of Bright Golden Anne (relative to lighting treatment)

Stick date	Lighting treatment	Leaf analyses					
		DM Oven %	N %	Total P %	Total K %	Total Mg %	Mn mg/kg
Week 43	A	7.2	5.56	1.26	5.94	0.83	300
Week 47		6.3	5.24	0.96	6.50	0.96	365
Week 43	B	6.1	5.77	1.44	5.98	0.90	325
Week 47		6.0	5.01	1.32	6.74	1.12	380
Week 43	C	6.5	5.76	1.24	5.53	0.82	305
Week 47		6.5	5.14	1.30	6.54	1.10	395
Week 43	D	6.4	5.59	1.52	5.75	0.90	355
Week 47		7.2	5.45	1.13	5.95	0.98	353

Lighting treatment

- A. No supplementary light
- B. Supplementary light at 5000 lux during weeks 1-2 of short days.
- C. Supplementary light at 5000 lux during weeks 1-3 of short days.
- D. Supplementary light at 2000 lux throughout short days.

APPENDIX IV.

TRIAL 2. Yoder Varieties - Tables of Results

APPENDIX IV.

Table 1. Effect of L.D. and S.D. lighting treatment on production time of Yoder varieties.

Variety: *Yuba*

Stick date	Number of days from sticking to marketing					
	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	80.9 ^a	78.8	82.2	71.2	71.8	73.9
Week 44/45	79.9	75.1	78.1	73.2	70.0	69.9
Week 48/49	81.6	76.3	80.0	74.2	69.6	72.2
(Mean)	(80.8)	(76.7)	(80.1)	(72.9)	(70.5)	(72.0)

Stick date	Number of days from start of S.D. to marketing					
	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Mean (of 3)	59.8	55.7	59.1	58.9	56.5	58.0

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 10 replicate pots per treatment per stick date.

APPENDIX IV.

Table 2. Effect of L.D. and S.D. lighting treatment on production time of Yoder varieties.

Variety: *Dark Yellow Boaldi*

Stick date	Number of days from sticking to marketing					
	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	80.1 ^a	77.5	81.3	69.3	68.9	72.3
Week 44/45	81.3	76.2	78.3	74.1	68.6	71.9
Week 48/49	79.2	75.0	78.4	72.8	68.2	70.5
(Mean)	(80.2)	(76.2)	(79.3)	(72.1)	(68.6)	(71.6)

Stick date	Number of days from start of S.D. to marketing					
	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Mean (of 3)	59.2	55.2	58.3	58.1	54.6	57.6

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 10 replicate pots per treatment per stick date.

APPENDIX IV.

Table 3. Effect of L.D. and S.D. lighting treatment on production time of Yoder varieties.

Variety: *Surf*

Stick date	Number of days from sticking to marketing					
	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	75.2 ^a	74.1	80.1	68.4	67.2	73.9
Week 44/45	77.4	71.3	73.9	72.4	66.2	67.1
Week 48/49	79.4	73.5	76.8	72.9	67.8	68.8
(Mean)	(77.3)	(73.0)	(76.9)	(71.2)	(67.1)	(69.9)

Stick date	Number of days from start of S.D. to marketing					
	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Mean (of 3)	56.3	52.0	55.9	57.2	53.1	55.9

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 10 replicate pots per treatment per stick date.

APPENDIX IV.

Table 4. Effect of L.D. and S.D. lighting treatment on production time of Yoder varieties.

Variety: *Charm*

Stick date	Number of days from sticking to marketing					
	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	73.8 ^a	74.7	76.7	67.8	67.2	69.0
Week 44/45	77.5	72.9	75.0	71.8	66.7	70.0
Week 48/49	78.8	74.3	76.0	71.3	67.1	68.7
(Mean)	(76.7)	(74.0)	(75.9)	(70.3)	(67.0)	(69.2)

Stick date	Number of days from start of S.D. to marketing					
	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Mean (of 3)	55.7	53.0	54.9	56.3	53.0	55.2

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 10 replicate pots per treatment per stick date.

APPENDIX IV.

Table 5. Effect of L.D. and S.D. lighting treatments on plant height of Yoder varieties

Variety: *Yuba*

Stick date	Plant height (cm) relative to lighting treatment					
	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	23.0 ^a	25.0	21.9	24.1	25.4	22.2
Week 44/45	23.3	22.5	21.4	23.8	23.4	20.7
Week 48/49	19.8	20.5	19.0	22.1	21.2	20.1
(Mean)	(22.0)	(22.7)	(20.8)	(23.3)	(23.4)	(21.0)

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 5 plants per pot for 10 replicate pots per treatment per stick date.

APPENDIX IV.

Table 6. Effect of L.D. and S.D. lighting treatments on plant height of Yoder varieties

Variety: *Dark Yellow Boaldi*

Stick date	Plant height (cm) relative to lighting treatment					
	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	19.8 ^a	23.5	19.3	21.8	23.8	21.0
Week 44/45	22.0	22.9	22.4	21.4	23.7	22.4
Week 48/49	17.8	20.4	17.5	19.7	21.1	18.3
(Mean)	(19.9)	(22.3)	(19.7)	(21.0)	(22.9)	(20.6)

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 5 plants per pot for 10 replicate pots per treatment per stick date.

APPENDIX IV.

Table 7. Effect of L.D. and S.D. lighting treatments on plant height of Yoder varieties

Variety: *Surf*

Stick date	Plant height (cm) relative to lighting treatment					
	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	24.0 ^a	27.0	21.2	22.3	22.9	21.0
Week 44/45	25.0	25.4	23.4	26.1	25.6	23.5
Week 48/49	21.4	21.4	20.5	23.0	22.7	21.1
(Mean)	(23.4)	(24.6)	(21.7)	(23.8)	(23.7)	(21.9)

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 5 plants per pot for 10 replicate pots per treatment per stick date.

APPENDIX IV.

Table 8. Effect of L.D. and S.D. lighting treatments on plant height of Yoder varieties

Variety: *Charm*

Stick date	Plant height (cm) relative to lighting treatment					
	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	21.0 ^a	24.8	21.3	19.2	21.9	20.4
Week 44/45	20.5	21.7	20.4	20.5	22.2	19.6
Week 48/49	18.8	21.4	18.1	20.3	19.9	19.5
(Mean)	(20.1)	(22.6)	(19.9)	(20.0)	(21.3)	(19.8)

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 5 plants per pot for 10 replicate pots per treatment per stick date.

APPENDIX IV.

Table 9. Effect of L.D. and S.D. lighting treatments on uniformity of plant height per pot (assessed as standard deviation of plant height) of Yoder varieties.

Variety: *Yuba*

Stick date	Standard deviation from average of plant height per plant per pot relative to lighting treatment					
	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	4.79 ^a	5.00	4.67	4.90	5.04	4.71
Week 44/45	4.82	4.75	4.62	4.88	4.84	4.55
Week 48/49	4.45	4.52	4.36	4.70	4.61	4.48
(Mean)	(4.69)	(4.76)	(4.55)	(4.83)	(4.83)	(4.58)

S.D. Lighting treatment

A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 5 plants per pot for 10 replicate pots per treatment per stick date.

APPENDIX IV.

Table 10. Effect of L.D. and S.D. lighting treatments on uniformity of plant height per pot (assessed as standard deviation of plant height) of Yoder varieties.Variety: *Dark Yellow Boaldi*

Stick date	Standard deviation from average of plant height per plant per pot relative to lighting treatment					
	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	4.44 ^a	4.84	4.39	4.66	4.88	4.58
Week 44/45	4.67	4.79	4.73	4.63	4.86	4.73
Week 48/49	4.22	4.52	4.19	4.44	4.59	4.28
(Mean)	(4.45)	(4.71)	(4.44)	(4.58)	(4.78)	(4.53)

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 5 plants per pot for 10 replicate pots per treatment per stick date.

APPENDIX IV.

Table 11. Effect of L.D. and S.D. lighting treatments on uniformity of plant height per pot (assessed as standard deviation of plant height) of Yoder varieties.Variety: *Surf*

Stick date	Standard deviation from average of plant height per plant per pot relative to lighting treatment					
	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	4.89 ^a	5.20	4.61	4.72	4.77	4.58
Week 44/45	5.00	5.04	4.84	5.11	5.06	4.84
Week 48/49	4.62	4.62	4.53	4.79	4.76	4.59
(Mean)	(4.84)	(5.00)	(4.66)	(4.87)	(4.86)	(4.67)

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 5 plants per pot for 10 replicate pots per treatment per stick date.

APPENDIX IV.

Table 12. Effect of L.D. and S.D. lighting treatments on uniformity of plant height per pot (assessed as standard deviation of plant height) of Yoder varieties.Variety: *Charm*

Stick date	Standard deviation from average of plant height per plant per pot relative to lighting treatment					
	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	4.58 ^a	4.98	4.62	4.38	4.68	4.51
Week 44/45	4.52	4.66	4.51	4.53	4.71	4.43
Week 48/49	4.33	4.62	4.25	4.50	4.46	4.41
(Mean)	(4.48)	(4.75)	(4.46)	(4.47)	(4.62)	(4.45)

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 5 plants per pot for 10 replicate pots per treatment per stick date.

APPENDIX IV.

Table 13. Effect of L.D. and S.D. lighting treatments on pot spread of Yoder varieties.

Variety: *Yuba*

Stick date	Spread	Response to lighting treatment - Spread (cm)					
		L.D. - UNLIT			L.D. - LIT		
		A	B	C	A	B	C
Week 40/41	Maximum	37.5 ^a	35.7	35.7	38.7	35.8	35.2
	Minimum	34.7	32.9	32.3	33.7	32.5	32.5
	Ratio	1.08	1.09	1.11	1.15	1.13	1.08
Week 44/45	Maximum	41.3	36.0	39.4	40.2	38.8	36.8
	Minimum	36.5	34.3	36.1	37.3	34.7	33.3
	Ratio	1.13	1.05	1.10	1.08	1.12	1.11
Week 48/49	Maximum	39.4	35.6	39.0	40.0	37.6	40.0
	Minimum	35.7	31.8	35.3	37.4	32.7	36.0
	Ratio	1.10	1.12	1.11	1.07	1.16	1.11
Mean (of 3)	Maximum	39.4	35.8	38.0	39.6	37.4	37.3
	Minimum	35.6	33.0	34.6	36.1	33.1	33.9
	Ratio	1.12	1.09	1.10	1.10	1.14	1.10

S.D. Lighting treatment

A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 10 replicate pots per treatment per stick date.

APPENDIX IV.

Table 14. Effect of L.D. and S.D. lighting treatments on pot spread of Yoder varieties.

Variety: *Dark Yellow Boaldi*

Stick date	Spread	Response to lighting treatment - Spread (cm)					
		L.D. - UNLIT			L.D. - LIT		
		A	B	C	A	B	C
Week 40/41	Maximum	39.4 ^a	40.0	38.8	37.3	40.5	38.9
	Minimum	35.6	35.1	33.6	33.6	37.2	35.0
	Ratio	1.14	1.14	1.16	1.11	1.09	1.12
Week 44/45	Maximum	44.3	42.5	42.2	42.2	44.5	40.9
	Minimum	39.5	38.0	38.3	38.7	38.2	38.0
	Ratio	1.12	1.12	1.10	1.09	1.18	1.08
Week 48/49	Maximum	39.1	39.7	39.2	42.7	39.0	40.6
	Minimum	36.4	36.8	35.2	37.6	37.0	36.2
	Ratio	1.09	1.08	1.11	1.13	1.05	1.12
Mean (of 3)	Maximum	40.9	40.7	40.1	40.7	41.3	40.1
	Minimum	37.2	36.6	35.7	36.6	37.5	36.4
	Ratio	1.11	1.11	1.13	1.11	1.11	1.11

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 10 replicate pots per treatment per stick date.

APPENDIX IV.

Table 15. Effect of L.D. and S.D. lighting treatments on pot spread of Yoder varieties.

Variety: *Surf*

Stick date	Spread	Response to lighting treatment - Spread (cm)					
		L.D. - UNLIT			L.D. - LIT		
		A	B	C	A	B	C
Week 40/41	Maximum	37.5 ^a	39.6	36.7	37.3	37.0	38.8
	Minimum	34.7	35.0	33.4	33.2	33.6	34.9
	Ratio	1.08	1.13	1.10	1.12	1.10	1.11
Week 44/45	Maximum	42.7	38.6	40.5	44.9	40.5	40.9
	Minimum	38.3	35.1	36.1	40.1	37.2	37.3
	Ratio	1.11	1.10	1.12	1.12	1.09	1.10
Week 48/49	Maximum	41.1	37.8	38.9	42.1	39.3	40.8
	Minimum	36.6	34.6	35.0	39.4	34.6	35.8
	Ratio	1.13	1.10	1.11	1.07	1.14	1.14
Mean (of 3)	Maximum	40.4	38.7	38.7	41.4	38.9	40.2
	Minimum	36.5	34.9	34.8	37.6	35.1	36.0
	Ratio	1.11	1.11	1.11	1.11	1.11	1.11

S.D. Lighting treatment

A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 10 replicate pots per treatment per stick date.

APPENDIX IV.

Table 16. Effect of L.D. and S.D. lighting treatments on pot spread of Yoder varieties.

Variety: *Charm*

Stick date	Spread	Response to lighting treatment - Spread (cm)					
		L.D. - UNLIT			L.D. - LIT		
		A	B	C	A	B	C
Week 40/41	Maximum	35.2 ^a	35.7	37.1	32.9	36.1	33.2
	Minimum	31.5	32.7	32.4	30.3	31.0	31.0
	Ratio	1.12	1.10	1.15	1.09	1.12	1.07
Week 44/45	Maximum	39.2	38.3	38.0	38.3	38.5	36.8
	Minimum	35.0	33.7	33.7	35.2	34.6	32.3
	Ratio	1.12	1.14	1.13	1.09	1.11	1.15
Week 48/49	Maximum	36.0	38.1	36.3	38.2	35.6	38.4
	Minimum	32.2	34.7	33.0	34.2	33.5	34.2
	Ratio	1.12	1.10	1.10	1.12	1.07	1.13
Mean (of 3)	Maximum	36.8	37.4	37.1	36.5	36.7	36.1
	Minimum	32.9	33.7	33.0	33.2	33.5	32.5
	Ratio	1.12	1.11	1.13	1.10	1.10	1.11

S.D. Lighting treatment

A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 10 replicate pots per treatment per stick date.

APPENDIX IV.

Table 17. Effect of L.D. and S.D. lighting treatment on bud development of Yoder varieties.

Variety: *Yuba*

Average number of buds at stages 3 and 4 relative to lighting treatment

Stick date	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	25.8 ^a	29.7	38.0	29.4	29.0	33.1
Week 44/45	23.5	36.8	46.4	29.0	39.2	49.6
Week 48/49	35.4	28.9	41.3	47.4	37.2	43.9
(Mean)	(28.2)	(31.8)	(41.9)	(34.9)	(35.1)	(42.2)

Average number of buds at stages 5 and above relative to lighting treatment

Stick date	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	6.6 ^a	5.4	5.7	6.2	5.9	12.5
Week 44/45	5.7	5.1	5.5	4.6	7.9	7.7
Week 48/49	4.8	4.9	5.1	7.4	5.7	5.3
(Mean)	(5.7)	(5.1)	(5.4)	(6.1)	(6.8)	(8.5)

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 10 replicate pots per treatment per stick date.

APPENDIX IV.

Table 18. Effect of L.D. and S.D. lighting treatment on bud development of Yoder varieties.

Variety: *Dark Yellow Boaldi*

Average number of buds at stages 3 and 4 relative to lighting treatment

Stick date	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	29.7 ^a	34.5	36.3	30.9	41.1	36.9
Week 44/45	28.1	36.1	43.6	29.1	38.4	44.7
Week 48/49	26.0	35.1	27.0	34.6	36.8	34.6
(Mean)	(27.9)	(35.2)	(35.6)	(31.5)	(38.8)	(38.7)

Average number of buds at stages 5 and above relative to lighting treatment

Stick date	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	4.6 ^a	7.0	4.9	8.1	8.4	9.9
Week 44/45	7.4	4.9	3.9	5.9	6.9	4.9
Week 48/49	3.4	8.4	3.1	6.0	5.9	4.9
(Mean)	(5.1)	(6.8)	(4.0)	(6.7)	(7.1)	(7.2)

S.D. Lighting treatment

A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 10 replicate pots per treatment per stick date.

APPENDIX IV.

Table 19. Effect of L.D. and S.D. lighting treatment on bud development of Yoder varieties.

Variety: *Surf*

Average number of buds at stages 3 and 4 relative to lighting treatment

Stick date	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	21.8 ^a	23.4	24.4	21.0	21.8	29.9
Week 44/45	21.2	30.3	37.7	21.2	34.4	36.1
Week 48/49	30.1	15.6	29.6	31.9	26.7	28.7
(Mean)	(24.4)	(23.1)	(30.6)	(24.7)	(27.6)	(31.6)

Average number of buds at stages 5 and above relative to lighting treatment

Stick date	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	10.6 ^a	12.0	9.4	9.5	9.8	13.0
Week 44/45	2.9	4.3	9.5	6.6	10.1	10.3
Week 48/49	4.0	9.2	5.6	8.3	6.7	3.9
(Mean)	(5.8)	(8.5)	(8.2)	(8.1)	(8.9)	(9.1)

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 10 replicate pots per treatment per stick date.

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Table 20. Effect of L.D. and S.D. lighting treatment on bud development of Yoder varieties.

Variety: *Charm*

Average number of buds at stages 3 and 4 relative to lighting treatment						
Stick date	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	26.7 ^a	30.3	30.1	21.3	25.4	32.8
Week 44/45	27.5	33.4	40.0	24.3	35.1	35.0
Week 48/49	24.0	26.0	26.0	24.7	22.8	28.8
(Mean)	(26.1)	(29.9)	(32.2)	(23.4)	(27.8)	(32.2)

Average number of buds at stages 5 and above relative to lighting treatment						
Stick date	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	7.1 ^a	7.2	3.5	6.1	10.6	3.5
Week 44/45	4.0	6.7	5.8	4.8	6.5	5.5
Week 48/49	3.3	10.6	5.8	2.8	7.1	5.3
(Mean)	(4.8)	(8.2)	(5.0)	(4.6)	(8.1)	(4.8)

S.D. Lighting treatment

A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 10 replicate pots per treatment per stick date.

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Table 21. Effect of L.D. and S.D. lighting treatment on total numbers of buds produced by Yoder varieties.

Variety: *Yuba*

Stick date	Total bud count per pot relative to lighting treatment					
	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	49.0	56.6	63.9	52.6	54.4	67.0
Week 44/45	43.0	50.4	65.1	46.7	54.8	69.2
Week 48/49	59.5	61.5	70.4	70.5	60.5	77.8
(Mean)	(50.5)	(56.2)	(66.5)	(56.6)	(56.6)	(71.3)

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 10 replicate pots per treatment per stick date.

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Table 22. Effect of L.D. and S.D. lighting treatment on total numbers of buds produced by Yoder varieties.Variety: *Dark Yellow Boaldi*

Stick date	Total bud count per pot relative to lighting treatment					
	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	44.6 ^a	49.2	57.3	48.2	59.1	70.8
Week 44/45	43.8	46.4	58.9	41.6	51.1	59.7
Week 48/49	58.2	61.9	65.4	66.4	66.4	74.1
(Mean)	(48.9)	(52.5)	(60.5)	(52.1)	(58.9)	(68.2)

S.D. Lighting treatment

A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 10 replicate pots per treatment per stick date.

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Table 23. Effect of L.D. and S.D. lighting treatment on total numbers of buds produced by Yoder varieties.

Variety: *Surf*

Stick date	Total bud count per pot relative to lighting treatment					
	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	40.7 ^a	50.5	55.2	38.4	39.0	57.4
Week 44/45	35.7	47.1	55.4	36.1	53.9	56.1
Week 48/49	53.2	46.2	60.1	56.9	57.7	60.5
(Mean)	(43.2)	(47.9)	(56.9)	(43.8)	(50.2)	(58.0)

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 10 replicate pots per treatment per stick date.

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Table 24. Effect of L.D. and S.D. lighting treatment on total numbers of buds produced by Yoder varieties.

Variety: *Charm*

Stick date	Total bud count per pot relative to lighting treatment					
	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	35.0 ^a	46.8	52.7	32.7	42.3	50.1
Week 44/45	46.7	52.7	63.0	45.6	57.5	55.6
Week 48/49	63.0	57.9	66.1	66.7	57.1	73.9
(Mean)	(48.2)	(52.5)	(56.9)	(48.3)	(52.3)	(58.0)

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 10 replicate pots per treatment per stick date.

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Table 25. Effect of L.D. and S.D. lighting treatment on uniformity of flowering (average maximum bud stage per plant) of Yoder varieties.Variety: *Yuba*

Stick date	Average maximum bud stage per plant relative to lighting treatment					
	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	5.3 ^a	5.0	5.1	5.1	5.2	5.4
Week 44/45	4.7	5.0	5.0	5.0	5.4	5.3
Week 48/49	4.9	4.7	5.0	5.2	5.0	5.2
(Mean)	(5.0)	(4.9)	(5.0)	(5.1)	(5.2)	(5.3)

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 10 replicate pots per treatment per stick date.

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Table 26. Effect of L.D. and S.D. lighting treatment on uniformity of flowering (average maximum bud stage per plant) of Yoder varieties.

Variety: *Dark Yellow Boaldi*

Stick date	Average maximum bud stage per plant relative to lighting treatment					
	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	5.0 ^a	5.2	5.3	5.2	5.1	5.2
Week 44/45	4.8	4.9	4.8	4.7	5.0	5.1
Week 48/49	4.5	5.0	4.7	4.9	4.7	5.0
(Mean)	(4.7)	(5.0)	(4.9)	(4.9)	(5.0)	(5.1)

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 10 replicate pots per treatment per stick date.

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Table 27. Effect of L.D. and S.D. lighting treatment on uniformity of flowering (average maximum bud stage per plant) of Yoder varieties.

Variety: *Surf*

Average maximum bud stage per plant relative to lighting treatment

Stick date	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	5.1 ^a	5.3	5.4	5.0	4.9	5.5
Week 44/45	4.1	4.9	5.3	5.2	5.2	5.0
Week 48/49	4.8	5.0	4.7	5.2	4.7	4.5
(Mean)	(4.7)	(5.1)	(5.1)	(5.1)	(4.9)	(5.0)

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 10 replicate pots per treatment per stick date.

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Table 28. Effect of L.D. and S.D. lighting treatment on uniformity of flowering (average maximum bud stage per plant) of Yoder varieties.

Variety: *Charm*

Stick date	Average maximum bud stage per plant relative to lighting treatment					
	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	5.2 ^a	5.1	4.7	5.4	5.3	4.9
Week 44/45	4.8	5.2	5.0	5.0	4.9	5.0
Week 48/49	4.7	5.5	5.0	4.8	5.2	5.0
(Mean)	(4.9)	(5.2)	(4.9)	(5.0)	(5.1)	(5.0)

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 10 replicate pots per treatment per stick date.

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Table 29. Effect of L.D. and S.D. lighting treatment on uniformity of flowering per pot (assessed as standard deviation of maximum bud stage per plant per pot) of Yoder varieties.

Variety: *Yuba*

Standard deviation from average of maximum bud stage per plant per pot
relative to lighting treatment

Stick date	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	0.66 ^a	0.86	0.85	0.87	0.71	0.68
Week 44/45	1.20	0.78	0.87	0.93	0.84	0.66
Week 48/49	1.00	1.10	0.82	0.77	0.94	0.78
(Mean)	(0.96)	(0.91)	(0.85)	(0.86)	(0.83)	(0.71)

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 10 replicate pots per treatment per stick date.

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Table 30. Effect of L.D. and S.D. lighting treatment on uniformity of flowering per pot (assessed as standard deviation of maximum bud stage per plant per pot) of Yoder varieties.

Variety: *Dark Yellow Boaldi*

Standard deviation from average of maximum bud stage per plant per pot
relative to lighting treatment

Stick date	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	0.89 ^a	0.76	0.72	0.93	0.77	0.87
Week 44/45	1.22	1.09	0.90	1.18	1.02	0.89
Week 48/49	1.30	1.10	1.02	1.01	1.14	0.89
(Mean)	(1.14)	(0.98)	(0.88)	(1.04)	(0.98)	(0.88)

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 10 replicate pots per treatment per stick date.

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Table 31. Effect of L.D. and S.D. lighting treatment on uniformity of flowering per pot (assessed as standard deviation of maximum bud stage per plant per pot) of Yoder varieties.

Variety: *Surf*

Standard deviation from average of maximum bud stage per plant per pot relative to lighting treatment

Stick date	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	1.06 ^a	0.61	0.75	1.01	1.01	0.56
Week 44/45	1.39	1.01	0.91	0.96	0.75	0.89
Week 48/49	1.10	0.87	1.18	0.75	1.09	1.16
(Mean)	(1.18)	(0.83)	(0.95)	(0.91)	(0.95)	(0.87)

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 10 replicate pots per treatment per stick date.

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Table 32. Effect of L.D. and S.D. lighting treatment on uniformity of flowering per pot (assessed as standard deviation of maximum bud stage per plant per pot) of Yoder varieties.

Variety: *Charm*

Standard deviation from average of maximum bud stage per plant per pot
relative to lighting treatment

Stick date	L.D. - UNLIT			L.D. - LIT		
	A	B	C	A	B	C
Week 40/41	0.83 ^a	0.91	0.82	0.63	0.69	0.82
Week 44/45	0.97	0.76	0.88	0.79	0.88	0.85
Week 48/49	1.04	0.66	0.79	0.96	0.83	0.85
(Mean)	(0.95)	(0.78)	(0.83)	(0.79)	(0.80)	(0.84)

S.D. Lighting treatment

A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 10 replicate pots per treatment per stick date.

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Table 33. Effect of lighting treatments on post production shelf life of Yoder varieties.

Variety: *Yuba*

Stick date	Shelf life stage	Number of days taken to deteriorate from shelf life stage 1 to stage 2 and stage 2 to stage 3		
		A	B	C
Week 40/41	1→2	9.3 ^a	9.6	11.7
	2→3	6.6	10.4	7.5
	(Total ^b)	(15.9)	(20.0)	(19.2)
Week 44/45	1→2	6.1	10.1	10.6
	2→3	9.2	10.9	7.6
	(Total)	(15.3)	(21.0)	(18.2)
Week 48/49	1→2	11.5	14.2	11.8
	2→3	8.9	12.8	11.6
	(Total)	(20.4)	(27.0)	(23.4)

S.D. Lighting treatment

A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 6 replicate pots per lighting treatment per stick date.

^b = Total time taken to deteriorate completely.

Note: No significant effect on shelf life of supplementary lighting during L.D. was noted hence only results from S.D. treatments are presented here.

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Table 34. Effect of lighting treatments on post production shelf life of Yoder varieties.

Variety: *Dark Yellow Boaldi*

Stick date	Shelf life stage	Number of days taken to deteriorate from shelf life stage 1 to stage 2 and stage 2 to stage 3		
		A	B	C
Week 40/41	1→2	7.6 ^a	11.4	10.2
	2→3	7.8	7.4	8.5
	(Total ^b)	(15.4)	(18.8)	(18.7)
Week 44/45	1→2	5.3	7.0	6.4
	2→3	12.8	9.9	12.3
	(Total)	(18.1)	(16.9)	(18.7)
Week 48/49	1→2	11.3	9.2	11.8
	2→3	9.6	12.2	11.6
	(Total)	(20.9)	(21.4)	(23.4)

S.D. Lighting treatment

A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 6 replicate pots per lighting treatment per stick date.^b = Total time taken to deteriorate completely.

Note: No significant effect on shelf life of supplementary lighting during L.D. was noted hence only results from S.D. treatments are presented here.

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Table 35. Effect of lighting treatments on post production shelf life of Yoder varieties.

Variety: *Surf*

Stick date	Shelf life stage	Number of days taken to deteriorate from shelf life stage 1 to stage 2 and stage 2 to stage 3		
		A	B	C
Week 40/41	1→2	11.7 ^a	12.9	12.3
	2→3	7.3	8.4	8.8
	(Total ^b)	(19.0)	(21.3)	(21.1)
Week 44/45	1→2	5.2	8.8	8.5
	2→3	8.3	11.9	22.5
	(Total)	(13.5)	(20.7)	(31.0)
Week 48/49	1→2	10.1	16.4	13.0
	2→3	12.9	11.6	13.9
	(Total)	(23.0)	(28.0)	(26.9)

S.D. Lighting treatment

A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 6 replicate pots per lighting treatment per stick date.^b = Total time taken to deteriorate completely.

Note: No significant effect on shelf life of supplementary lighting during L.D. was noted hence only results from S.D. treatments are presented here.

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Table 36. Effect of lighting treatments on post production shelf life of Yoder varieties.

Variety: *Charm*

Stick date	Shelf life stage	Number of days taken to deteriorate from shelf life stage 1 to stage 2 and stage 2 to stage 3		
		A	B	C
Week 40/41	1→2	13.8 ^a	11.3	7.1
	2→3	11.9	11.2	12.1
	(Total ^b)	(25.7)	(22.5)	(19.2)
Week 44/45	1→2	8.2	7.4	5.9
	2→3	12.0	11.1	8.0
	(Total)	(20.2)	(18.5)	(13.9)
Week 48/49	1→2	10.3	12.7	10.7
	2→3	10.7	9.7	9.5
	(Total)	(21.0)	(22.4)	(20.2)

S.D. Lighting treatment

A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 6 replicate pots per lighting treatment per stick date.^b = Total time taken to deteriorate completely.

Note: No significant effect on shelf life of supplementary lighting during L.D. was noted hence only results from S.D. treatments are presented here.

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Table 37. Effect of lighting treatment on subsequent bud expansion during shelf life of Yoder varieties (assessed at shelf life stage 2).

Variety: *Yuba*

Stick date	Bud stage	Number of buds at stages 3, 4, 5 and above at shelf life stage 2 relative to lighting treatment		
		A	B	C
Week 40/41	3, 4	7.2 ^a	6.4	16.5
	5, 5+	32.3	31.8	37.9
	(Total ^b)	(57.4)	(58.8)	(73.6)
Week 44/45	3, 4	8.6	11.1	24.8
	5, 5+	26.1	33.5	32.7
	(Total)	(44.1)	(50.3)	(66.8)
Week 48/49	3, 4	18.9	11.1	23.6
	5, 5+	31.7	39.7	35.0
	(Total)	(62.7)	(62.5)	(71.4)

S.D. Lighting treatment

A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 6 replicate pots per lighting treatment per stick date.

^b = TOTAL ie. all potential buds and open flowers.

Note:

No significant effect of supplementary lighting during L.D. on bud expansion during shelf life was noted, hence only results from S.D. treatments are presented here.

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Table 38. Effect of lighting treatment on subsequent bud expansion during shelf life of Yoder varieties (assessed at shelf life stage 2).

Variety: *Dark Yellow Boaldi*

Stick date	Bud stage	Number of buds at stages 3, 4, 5 and above at shelf life stage 2 relative to lighting treatment		
		A	B	C
Week 40/41	3, 4	3.4 ^a	2.9	11.1
	5, 5+	36.9	38.6	42.9
	(Total ^b)	(53.7)	(60.0)	(70.9)
Week 44/45	3, 4	11.8	8.4	15.2
	5, 5+	23.2	34.5	37.2
	(Total)	(40.1)	(48.0)	(58.1)
Week 48/49	3, 4	15.6	9.3	16.8
	5, 5+	34.6	43.4	35.0
	(Total)	(64.3)	(62.8)	(69.7)

S.D. Lighting treatment

A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 6 replicate pots per lighting treatment per stick date.^b = Total ie. all potential buds and open flowers.**Note:**

No significant effect of supplementary lighting during L.D. on bud expansion during shelf life was noted, hence only results from S.D. treatments are presented here.

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Table 39. Effect of lighting treatment on subsequent bud expansion during shelf life of Yoder varieties (assessed at shelf life stage 2).Variety: *Surf*

Stick date	Bud stage	Number of buds at stages 3, 4, 5 and above at shelf life stage 2 relative to lighting treatment		
		A	B	C
Week 40/41	3, 4	3.9 ^a	3.6	9.7
	5, 5+	27.3	29.8	37.9
	(Total ^b)	(44.7)	(51.5)	(61.5)
Week 44/45	3, 4	11.1	5.1	18.2
	5, 5+	20.6	35.3	35.6
	(Total)	(39.5)	(49.1)	(58.9)
Week 48/49	3, 4	12.0	4.5	9.1
	5, 5+	36.6	36.2	43.1
	(Total)	(54.7)	(52.4)	(63.5)

S.D. Lighting treatment

A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 6 replicate pots per lighting treatment per stick date.^b = Total ie. all potential buds and open flowers.**Note:**

No significant effect of supplementary lighting during L.D. on bud expansion during shelf life was noted, hence only results from S.D. treatments are presented here.

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Table 40. Effect of lighting treatment on subsequent bud expansion during shelf life of Yoder varieties (assessed at shelf life stage 2).Variety: *Charm*

Stick date	Bud stage	Number of buds at stages 3, 4, 5 and above at shelf life stage 2 relative to lighting treatment		
		A	B	C
Week 40/41	3, 4	4.6 ^a	9.0	9.3
	5, 5+	27.0	30.0	31.3
	(Total ^b)	(45.6)	(53.1)	(56.9)
Week 44/45	3, 4	10.2	12.4	17.0
	5, 5+	23.8	29.6	27.5
	(Total)	(44.3)	(54.1)	(57.7)
Week 48/49	3, 4	13.1	8.4	13.3
	5, 5+	30.3	32.5	36.5
	(Total)	(64.4)	(55.4)	(70.5)

S.D. Lighting treatment

A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 6 replicate pots per lighting treatment per stick date.^b = Total ie. all potential buds and open flowers.**Note:**

No significant effect of supplementary lighting during L.D. on bud expansion during shelf life was noted, hence only results from S.D. treatments are presented here.

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Table 41. Compost analyses of Yoder varieties at marketing relative to lighting treatment.

Variety: *Yuba*

Stick date	Lighting treatment		Compost Analyses						
	L.D.	S.D.	pH	P mg/l	K mg/l	Mg mg/l	Cond μ S	NO ₃ -N mg/l	NH ₄ -N mg/l
40/41	Unlit	A	5.7	18	17	29	108	1	1
44/45	"	"	5.4	14	16	42	162	56	2
48/49	"	"	5.4	9	35	38	155	53	2
40/41	Unlit	B	5.9	19	11	24	100	2	1
44/45	"	"	5.4	18	32	29	145	43	2
48/49	"	"	6.1	8	28	11	77	16	1
40/41	Unlit	C	5.7	21	17	40	137	1	1
44/45	"	"	5.8	10	18	29	126	35	1
48/49	"	"	5.4	11	40	62	228	82	3
40/41	Lit	A	5.9	10	24	25	106	20	1
44/45	"	"	5.9	7	12	20	107	41	3
48/49	"	"	5.4	11	41	64	207	60	1
40/41	Lit	B	5.9	16	20	22	92	14	1
44/45	"	"	6.0	8	22	17	115	34	1
48/49	"	"	6.1	9	11	9	65	5	2
40/41	Lit	C	5.8	11	1	45	148	1	1
44/45	"	"	5.8	10	24	30	146	53	2
48/49	"	"	5.4	10	44	70	253	78	1

S.D. Lighting treatment

A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

C. Supplementary lighting at 2000 lux throughout short days.

APPENDIX IV.

Table 42. Compost analyses of Yoder varieties at marketing relative to lighting treatment.

Variety: *Dark Yellow Boaldi*

Stick date	Lighting treatment		Compost Analyses						
	L.D.	S.D.	pH	P mg/l	K mg/l	Mg mg/l	Cond μ S	NO ₃ -N mg/l	NH ₄ -N mg/l
40/41	Unlit	A	5.6	44	11	98	263	15	5
44/45	"	"	5.4	9	16	95	344	158	3
48/49	"	"	5.4	6	23	95	311	86	1
40/41	Unlit	B	5.7	23	31	62	229	29	7
44/45	"	"	5.6	8	39	71	293	108	5
48/49	"	"	5.4	9	51	98	337	152	3
40/41	Unlit	C	5.7	17	14	53	175	4	3
44/45	"	"	5.6	9	31	69	286	108	2
48/49	"	"	5.3	3	30	61	251	96	3
40/41	Lit	A	5.6	15	28	55	178	27	1
44/45	"	"	5.8	2	7	53	215	83	2
48/49	"	"	5.3	4	23	164	480	210	5
40/41	Lit	B	5.8	20	44	43	159	9	1
44/45	"	"	5.9	5	26	57	244	86	1
48/49	"	"	5.9	7	31	39	183	57	1
40/41	Lit	C	5.6	21	7	99	165	2	3
44/45	"	"	5.8	5	18	48	205	69	3
48/49	"	"	5.1	5	63	110	405	123	2

S.D. Lighting treatment

A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

C. Supplementary lighting at 2000 lux throughout short days.

APPENDIX IV.

Table 43. Compost analyses of Yoder varieties at marketing relative to lighting treatment.

Variety: *Surf*

Stick date	Lighting treatment		Compost Analyses						
	L.D.	S.D.	pH	P mg/l	K mg/l	Mg mg/l	Cond μ S	NO ₃ -N mg/l	NH ₄ -N mg/l
40/41	Unlit	A	5.7	25	10	56	178	2	1
44/45	"	"	5.5	12	4	51	213	75	1
48/49	"	"	5.4	9	36	62	267	76	6
40/41	Unlit	B	5.8	22	21	45	151	1	1
44/45	"	"	5.6	16	22	53	204	65	2
48/49	"	"	5.7	12	35	44	192	74	3
40/41	Unlit	C	5.6	26	15	62	186	5	3
44/45	"	"	5.4	20	18	75	231	67	2
48/49	"	"	5.2	10	56	110	381	154	2
40/41	Lit	A	6.0	9	1	37	120	8	1
44/45	"	"	5.5	5	6	65	217	97	3
48/49	"	"	5.3	8	18	103	313	97	3
40/41	Lit	B	5.7	25	13	58	188	13	1
44/45	"	"	5.7	11	24	41	207	74	8
48/49	"	"	5.8	12	27	52	201	69	3
40/41	Lit	C	5.8	16	10	37	137	19	5
44/45	"	"	5.7	8	12	47	206	62	6
48/49	"	"	5.2	12	37	111	373	156	3

S.D. Lighting treatment

A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

C. Supplementary lighting at 2000 lux throughout short days.

APPENDIX IV.

Table 44. Compost analyses of Yoder varieties at marketing relative to lighting treatment.

Variety: *Charm*

Stick date	Lighting treatment		Compost Analyses						
	L.D.	S.D.	pH	P mg/l	K mg/l	Mg mg/l	Cond μ S	NO ₃ -N mg/l	NH ₄ -N mg/l
40/41	Unlit	A	5.7	13	18	28	120	31	1
44/45	"	"	5.6	10	10	54	210	92	3
48/49	"	"	5.2	14	30	99	303	133	3
40/41	Unlit	B	5.8	15	10	38	143	11	3
44/45	"	"	5.8	9	26	36	180	60	8
48/49	"	"	5.4	15	25	58	209	81	4
40/41	Unlit	C	5.9	13	9	36	151	8	3
44/45	"	"	5.7	15	44	54	246	90	3
48/49	"	"	4.8	14	53	121	398	168	3
40/41	Lit	A	5.8	13	6	40	132	1	2
44/45	"	"	5.6	6	4	36	165	70	2
48/49	"	"	5.3	7	7	97	290	104	3
40/41	Lit	B	6.0	8	5	21	87	1	1
44/45	"	"	5.8	8	24	35	170	60	3
48/49	"	"	5.6	13	28	54	184	81	3
40/41	Lit	C	5.9	20	25	35	145	1	3
44/45	"	"	5.9	7	13	24	133	45	3
48/49	"	"	4.9	11	58	140	454	211	3

S.D. Lighting treatment

A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

C. Supplementary lighting at 2000 lux throughout short days.

APPENDIX IV.

Table 45. Leaf analyses of Yoder varieties at marketing relative to lighting treatment.

Variety: *Yuba*

Stick date	Lighting treatment L.D. S.D.	Leaf Analyses					
		DM Oven %	N %	Total P %	Total K %	Total Mg %	Total Mn mg/kg
40/41	Unlit A	6.6	4.86	1.27	4.86	1.33	625
44/45	"	6.9	5.05	1.12	5.29	1.15	385
48/49	"	6.4	4.54	1.09	4.89	1.45	405
40/41	Unlit B	7.1	4.52	1.38	4.56	1.23	570
44/45	"	7.6	4.40	1.35	4.96	1.13	430
48/49	"	6.5	4.01	1.08	3.93	1.50	455
40/41	Unlit C	7.9	3.99	1.26	4.44	1.15	545
44/45	"	7.5	5.12	1.12	4.46	1.23	385
48/49	"	8.1	4.56	0.99	4.47	1.48	420
40/41	Lit A	6.5	4.76	1.25	5.51	1.25	480
44/45	"	5.9	5.06	1.30	4.97	1.28	365
48/49	"	7.1	4.50	1.10	4.60	1.43	450
40/41	Lit B	7.6	4.32	1.16	3.66	1.30	420
44/45	"	8.1	4.76	1.19	4.06	1.23	370
48/49	"	7.4	4.3	1.00	3.84	1.45	385
40/41	Lit C	8.0	4.16	1.20	3.69	1.25	430
44/45	"	6.7	4.88	1.17	4.23	1.28	355
48/49	"	8.2	4.73	0.99	4.29	1.38	400

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

APPENDIX IV.

Table 46. Leaf analyses of Yoder varieties at marketing relative to lighting treatment.

Variety: *Dark Yellow Boaldi*

Stick date	Lighting treatment L.D. S.D.	Leaf Analyses					
		DM Oven %	N %	Total P %	Total K %	Total Mg %	Total Mn mg/kg
40/41	Unlit A	5.5	6.55	1.50	6.93	0.75	485
44/45	"	6.1	5.53	1.55	6.94	0.78	325
48/49	"	7.3	5.56	1.25	5.66	1.03	310
40/41	Unlit B	6.7	6.11	1.35	6.01	0.74	430
44/45	"	7.6	5.48	1.46	4.99	0.93	310
48/49	"	6.0	4.50	1.41	5.83	1.13	365
40/41	Unlit C	6.9	5.23	1.25	5.05	0.73	485
44/45	"	9.1	5.78	1.34	4.95	0.95	270
48/49	"	6.6	5.59	1.44	6.33	0.98	290
40/41	Lit A	6.2	6.02	1.45	6.33	0.74	430
44/45	"	5.6	5.17	1.46	6.07	0.90	250
48/49	"	5.5	5.23	1.31	5.83	0.95	310
40/41	Lit B	6.0	6.47	1.19	5.83	0.74	360
44/45	"	7.0	4.10	1.21	4.83	0.90	245
48/49	"	5.7	4.69	1.43	4.88	1.13	340
40/41	Lit C	7.1	5.05	1.34	5.28	0.81	440
44/45	"	7.0	5.29	1.40	4.92	0.85	230
48/49	"	6.7	5.61	1.39	6.35	1.05	285

S.D. Lighting treatment

A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

C. Supplementary lighting at 2000 lux throughout short days.

APPENDIX IV.

Table 47. Leaf analyses of Yoder varieties at marketing relative to lighting treatment.

Variety: *Surf*

Stick date	Lighting treatment L.D. S.D.	Leaf Analyses					
		DM Oven %	N %	Total P %	Total K %	Total Mg %	Total Mn mg/kg
40/41	Unlit A	6.2	5.68	1.12	6.50	0.96	395
44/45	"	6.3	5.50	1.27	6.72	0.93	260
48/49	"	6.9	5.38	0.83	5.75	1.50	285
40/41	Unlit B	6.6	6.00	1.11	5.54	1.08	435
44/45	"	6.5	5.27	1.22	5.84	1.00	275
48/49	"	5.7	4.51	0.97	5.00	1.15	385
40/41	Unlit C	8.4	4.72	1.01	4.54	0.93	480
44/45	"	6.1	5.16	1.44	5.94	0.90	305
48/49	"	7.1	5.20	1.04	6.31	1.20	340
40/41	Lit A	6.5	6.12	1.13	5.97	0.98	300
44/45	"	5.9	5.16	1.19	6.44	0.98	186
48/49	"	5.6	5.18	0.97	5.73	1.18	295
40/41	Lit B	6.6	5.69	1.07	5.00	1.00	335
44/45	"	6.9	5.11	1.16	4.88	1.08	255
48/49	"	5.2	4.44	1.19	5.45	1.20	375
40/41	Lit C	6.8	5.28	1.03	5.72	0.84	350
44/45	"	6.8	5.62	0.96	4.81	0.98	240
48/49	"	7.4	5.33	0.97	6.35	1.20	275

S.D. Lighting treatment

A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

C. Supplementary lighting at 2000 lux throughout short days.

APPENDIX IV.

Table 48. Leaf analyses of Yoder varieties at marketing relative to lighting treatment.

Variety: *Charm*

Stick date	Lighting treatment L.D. S.D.	Leaf Analyses					
		DM Oven %	N %	Total P %	Total K %	Total Mg %	Total Mn mg/kg
40/41	Unlit A	6.5	4.60	1.69	5.20	0.77	405
44/45	"	7.1	5.33	1.29	5.47	0.85	280
48/49	"	5.9	4.62	1.26	6.06	0.98	405
40/41	Unlit B	7.5	4.63	1.42	4.16	0.72	400
44/45	"	7.6	4.79	1.25	4.61	0.88	310
48/49	"	7.2	4.33	1.26	4.69	1.05	375
40/41	Unlit C	6.0	5.20	1.61	5.06	0.75	380
44/45	"	6.3	4.96	1.36	4.96	1.00	300
48/49	"	6.7	4.85	1.29	5.79	0.98	360
40/41	Lit A	6.4	5.29	2.00	6.19	0.76	405
44/45	"	7.8	5.14	1.50	5.16	0.88	250
48/49	"	7.1	4.81	1.09	4.91	0.93	310
40/41	Lit B	6.9	4.93	1.50	4.80	0.70	370
44/45	"	7.5	5.01	1.33	4.43	0.83	245
48/49	"	8.4	4.35	1.30	4.44	0.93	310
40/41	Lit C	8.1	5.01	1.50	5.51	0.68	330
44/45	"	7.5	5.03	1.21	4.46	0.88	245
48/49	"	8.6	4.78	1.06	5.36	0.90	295

S.D. Lighting treatment

A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

C. Supplementary lighting at 2000 lux throughout short days.

APPENDIX V.

Trial 2. Observations on Yoder varieties - guard plants. Tables of results.

APPENDIX V.

**Table 1. Effect of lighting treatment on production time of Yoder varieties.
(Observation treatment on guards)**

Variety	Stick date	Number of days from sticking to marketing		
		L.D. - UNLIT (2 weeks)		
		A	B	C
Yuba	Week 41	69.0 ^a	68.5	73.3
	Week 45	75.3	68.8	70.5
	Week 49	75.3	66.7	71.3
Dark Yellow Boaldi	Week 41	68.7	69.7	70.8
	Week 45	74.8	67.7	72.3
	Week 49	73.0	66.8	70.0
Surf	Week 41	68.0	66.7	73.7
	Week 45	71.2	65.2	66.7
	Week 49	70.5	66.2	68.3
Charm	Week 41	68.2	67.8	69.0
	Week 45	73.7	67.3	69.3
	Week 49	72.0	66.2	68.5

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 6 replicate pots per treatment per stick date.

APPENDIX V.

Table 2. Effect of lighting treatment on production time of Yoder varieties (expressed as number of S.D.)
(Observation treatment on guards)

Variety	Number of days from start of S.D. to marketing		
	A	L.D. - UNLIT (2 weeks) B	C
Yuba	59.2 ^a	54.0	57.7
Dark Yellow Boaldi	58.2	54.1	57.0
Surf	55.9	52.0	55.6
Charm	57.3	53.1	54.9

S.D. Lighting treatment

- A. No Supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 3 sticking dates.

APPENDIX V.**Table 3. Effect of lighting treatment on production time of Yoder varieties.
(Observation treatment on guards)**

Variety	Stick date	Plant height (cm) relative to lighting treatment		
		L.D. - UNLIT (2 weeks)		
		A	B	C
Yuba	Week 41	19.7 ^a	22.8	20.9
	Week 45	23.2	21.0	20.1
	Week 49	20.4	20.0	18.7
Dark Yellow Boaldi	Week 41	19.7	21.7	20.4
	Week 45	25.4	21.6	20.8
	Week 49	18.2	19.4	17.7
Surf	Week 41	20.9	24.2	19.7
	Week 45	23.7	23.5	22.5
	Week 49	20.6	21.2	19.3
Charm	Week 41	17.1	21.8	18.8
	Week 45	18.9	20.3	17.9
	Week 49	18.7	19.0	18.2

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 5 plants per pot for treatment per stick date.

APPENDIX V.

Table 4. Effect of lighting treatment on pot spread of Yoder varieties (Observation treatment on guards).

Response to lighting treatment - Spread (cm)					
L.D. - UNLIT (2 weeks)					
Variety	Stick date		A	B	C
Yuba	Week 41	Max.	34.7 ^a	35.2	34.7
		Min.	31.8	31.5	32.2
	Week 45	Max.	38.3	35.5	36.8
		Min.	34.7	32.2	33.3
	Week 49	Max.	39.3	37.3	39.0
		Min.	36.7	33.3	35.3
Dark Yellow Boaldi	Week 41	Max.	38.0	38.8	36.3
		Min.	33.7	32.7	32.5
	Week 45	Max.	42.7	43.8	42.5
		Min.	37.5	38.2	40.5
	Week 49	Max.	40.5	41.0	40.0
		Min.	38.5	35.2	36.7

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 6 replicate pots per treatment per stick date.

APPENDIX V.

**Table 5. Effect of lighting treatment on pot spread of Yoder varieties - continued.
(Observation treatment on guards).**

Response to lighting treatment - Spread (cm)					
L.D. - UNLIT (2 weeks)					
Variety	Stick date		A	B	C
Surf	Week 41	Max.	38.0 ^a	36.2	35.2
		Min.	32.2	33.8	32.2
	Week 45	Max.	39.3	38.0	39.8
		Min.	34.0	34.5	36.2
	Week 49	Max.	39.0	39.2	40.3
		Min.	36.3	34.8	38.3
Charm	Week 41	Max.	37.0	36.2	34.2
		Min.	32.5	31.5	32.3
	Week 45	Max.	37.0	37.0	37.0
		Min.	31.8	34.8	33.3
	Week 49	Max.	36.5	35.5	37.2
		Min.	32.3	31.8	34.0

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 6 replicate pots per treatment per stick date.

APPENDIX V.

**Table 6. Effect of lighting treatment on bud development (stages 3 and 4) of Yoder varieties.
(Observation treatment on guards)**

		Average number of buds at stages 3 and 4 relative to lighting treatment		
		L.D. - UNLIT (2 weeks)		
Variety	Stick date	A	B	C
Yuba	Week 41	20.6 ^a	21.1	28.0
	Week 45	23.3	32.8	45.0
	Week 49	45.0	30.5	37.8
Dark Yellow Boaldi	Week 41	26.5	24.1	31.1
	Week 45	30.0	36.3	40.7
	Week 49	38.8	32.3	36.2
Surf	Week 41	16.0	19.3	29.6
	Week 45	16.0	32.5	33.5
	Week 49	26.2	26.7	30.8
Charm	Week 41	17.3	18.8	26.3
	Week 45	18.2	28.5	31.3
	Week 49	27.3	22.2	28.2

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 6 replicate pots per treatment per stick date.

APPENDIX V.

Table 7. Effect of lighting treatment on bud development (stages 5, 5+) of Yoder varieties. (Observation treatment on guards)

Variety	Stick date	Average number of buds at stages 5 and above relative to lighting treatment		
		L.D. - UNLIT (2 weeks)		
		A	B	C
Yuba	Week 41	13.0 ^a	16.0	11.8
	Week 45	4.3	3.0	6.3
	Week 49	6.8	7.8	5.5
Dark Yellow Boaldi	Week 41	12.2	13.3	11.7
	Week 45	5.5	8.3	5.8
	Week 49	12.7	11.5	5.5
Surf	Week 41	13.5	14.5	9.5
	Week 45	7.3	4.2	11.3
	Week 49	4.8	12.3	4.7
Charm	Week 41	8.6	11.3	9.3
	Week 45	6.7	5.5	3.8
	Week 49	4.0	9.5	6.2

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 6 replicate pots per treatment per stick date.

APPENDIX V.

Table 8. Effect of lighting treatment on total number of buds produced by Yoder varieties. (Observation treatment on guards)

Variety	Stick date	Total bud count per pot relative to lighting treatment		
		L.D. - UNLIT (2 weeks)		
		A	B	C
Yuba	Week 41	44.0	48.2	63.3
	Week 45	36.8	44.7	62.5
	Week 49	63.3	52.8	59.0
Dark Yellow Boaldi	Week 41	50.0	54.8	54.0
	Week 45	42.0	49.2	57.2
	Week 49	52.0	56.8	69.3
Surf	Week 41	41.5	45.3	51.5
	Week 45	29.2	50.2	51.7
	Week 49	52.7	46.8	61.5
Charm	Week 41	40.3	39.5	51.8
	Week 45	35.3	46.2	55.8
	Week 49	59.3	47.8	69.7

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 6 replicate pots per treatment per stick date.

APPENDIX V.

Table 9. Effect of lighting treatment on uniformity of flowering (average maximum bud stage per plant) of Yoder varieties. (Observation treatment on guards)

Variety	Stick date	Average maximum bud stage per plant relative to lighting treatment		
		L.D. - UNLIT (2 weeks)		
		A	B	C
Yuba	Week 14	5.2 ^a	5.3	5.4
	Week 45	5.0	4.5	5.0
	Week 49	5.3	5.1	5.0
Dark Yellow Boaldi	Week 41	5.0	5.3	5.2
	Week 45	5.1 [`]	5.2	4.9
	Week 49	5.4	5.4	4.8
Surf	Week 41	5.2	5.7	4.9
	Week 45	5.2	4.8	5.3
	Week 49	4.6	5.4	4.6
Charm	Week 41	5.2	5.6	5.3
	Week 45	5.2 [*]	4.8	4.7
	Week 49	4.8	5.4	5.0

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 5 plants per pot for 6 replicate pots per treatment per stick date.

APPENDIX V.

**Table 10. Effect of lighting treatments on post production shelf life of Yoder varieties.
(Observation treatment on guards)**

Variety: *Yuba*

Stick date	Shelf life stage	Number of days taken to deteriorate from shelf life stage 1 to stage 2 and stage 2 to stage 3		
		A	B	C
Week 41	1→2	8.6 ^a	11.0	10.8
	2→3	10.0	10.8	6.2
	(Total ^b)	(18.6)	(21.8)	(17.0)
Week 45	1→2	6.4	11.4	11.2
	2→3	11.6	11.0	4.6
	(Total)	(18.0)	(22.4)	(15.8)
Week 49	1→2	8.8	15.2	10.4
	2→3	10.2	11.6	11.4
	(Total)	(19.0)	(26.8)	(21.8)

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 6 replicate pots per lighting treatment per stick date.

^b = Total time taken to deteriorate completely.

APPENDIX V.

**Table 11. Effect of lighting treatments on post production shelf life of Yoder varieties.
(Observation treatment on guards)**

Variety: *Dark Yellow Boaldi*

Stick date	Shelf life stage	Number of days taken to deteriorate from shelf life stage 1 to stage 2 and stage 2 to stage 3		
		A	B	C
Week 41	1→2	8.8 ^a	10.6	10.2
	2→3	8.8	7.8	7.8
	(Total ^b)	(17.6)	(18.4)	(18.0)
Week 45	1→2	5.8	4.6	5.2
	2→3	13.8	8.2	11.2
	(Total)	(19.6)	(12.8)	(16.4)
Week 49	1→-2	12.4	9.4	12.4
	2→-3	6.6	10.6	13.2
	(Total)	(19.0)	(20.0)	(26.6)

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 6 replicate pots per lighting treatment per stick date.

^b = Total time taken to deteriorate completely.

APPENDIX V.

**Table 12. Effect of lighting treatments on post production shelf life of Yoder varieties.
(Observation treatment on guards)**

Variety: *Surf*

Stick date	Shelf life stage	Number of days taken to deteriorate from shelf life stage 1 to stage 2 and stage 2 to stage 3		
		A	B	C
Week 41	1→2	12.0 ^a	12.4	12.4
	2→3	6.6	7.4	7.3
	(Total ^b)	(18.6)	(19.8)	(19.7)
Week 45	1→2	5.2	7.4	15.2
	2→3	7.8	12.6	23.8
	(Total)	(13.0)	(20.0)	(39.0)
Week 49	1→2	10.8	14.4	12.0
	2→3	12.0	13.3	16.3
	(Total)	(22.8)	(27.7)	(28.3)

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 6 replicate pots per lighting treatment per stick date.

^b = Total time taken to deteriorate completely.

APPENDIX V.

Table 13. Effect of lighting treatment on post production shelf life of Yoder varieties.

Variety: *Charm*

Stick date	Shelf life stage	Number of days taken to deteriorate from shelf life stage 1 to stage 2 and stage 2 to stage 3		
		A	B	C
Week 41	1→2	13.2 ^a	11.0	7.6
	2→3	13.0	13.4	12.8
	(Total ^b)	(26.2)	(24.4)	(20.4)
Week 45	1→2	7.6	6.6	6.0
	2→3	11.4	9.8	9.6
	(Total)	(29.0)	(16.4)	(15.6)
Week 49	1→2	10.2	13.0	12.0
	2→3	13.8	11.5	10.0
	(Total)	(24.0)	(24.5)	(22.0)

S.D. Lighting treatment

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

^a = Mean of 6 replicate pots per lighting treatment per stick date.

^b = Total time taken to deteriorate completely.

APPENDIX VI.

Economic appraisal of lighting treatments

COST OF SUPPLEMENTARY LIGHTING FOR POT MUMS

Assumptions

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

2. Illuminance 5000 lux 1 lamp covers 6m².
 2000 lux 1 lamp covers 14 m².

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

$$\frac{£160 \times (80 \times 14\%)}{5 \text{ yrs } 100} = £43$$

4. Annual capital cost per m²

$$@ 5000 \text{ lux} = \frac{43}{6} = £7.17/\text{m}^2/\text{year}$$

$$@ 2000 \text{ lux} = \frac{43}{14} = £3.07/\text{m}^2/\text{year}$$

5. L.D. lighting for 24 hours/day.

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

7. Spacings

Bright Golden Anne	L.D.	41 pots/m ² (2 weeks)
	S.D. Intermediate	16 pots/m ² (3 weeks)
	S.D. Final	11.5 pots/m ²
Yoder varieties	L.D.	41 pots/m ² (2 or 3 weeks)
	S.D. Intermediate	24 pots/m ² (2 weeks)
	S.D. Final	12.5 pots/m ²

8. Lighting period October-February = 20 weeks.

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

- | | | | |
|------------------------------|----------|-----------------|--------------|
| 9. Electricity running costs | Standard | 7 am - midnight | 7.78 p/kW hr |
| | Off-Peak | Midnight - 7 am | 2.61 p/kW hr |

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

TRIAL 1: Bright Golden Anne

A. Capital cost

a. S.D. @ 5000 lux for 2 weeks at intermediate spacing (16 pots/m²)

1 m² will service 13 crops at 16 pots/m² = 208 pots

$$\text{Capital cost} = \frac{717}{208} = \underline{3.4\text{p/pot}}$$

b. S.D. @ 5000 lux for 3 weeks at intermediate spacing (16 pots/m²)

1 m² will service 9 crops at 16 pots/m² = 144 pots

$$\text{Capital cost} = \frac{717}{144} = \underline{5.0\text{p/pot}}$$

c. S.D. @ 2000 lux for 3 weeks at intermediate spacing 16 pots/m²

plus 6 weeks at final spacing 11.5 pots/m²

Calculations assume 9 week response from start of short days to flower when provided with supplementary lighting (standard response period for 'unlit' plants = 10 weeks)

at intermediate spacing 1 m² will service 9 crops at 16 pots/m² = 144 pots

$$\text{Capital cost} = \frac{307}{144} = \underline{2.13 \text{ p/pot}}$$

at final spacing 1 m² will service 4 crops at 11.5 pots/m² = 46 pots

$$\text{Capital cost} = \frac{307}{46} = \underline{6.67 \text{ p/pot}}$$

$$\text{Total Capital Cost} = 2.13 + 6.67 = 8.8 \text{ p/pot}$$

B. Running cost

- a. S.D. @ 5000 lux for 2 weeks at intermediate spacing (16 pots/m²)

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

@ 16 pots/m²

$$\text{Running cost per pot} = \frac{87.9}{16} = 5.5 \text{ p/pot}$$

- b. S.D. @ 5000 lux for 3 weeks at intermediate spacing (16 pots/m²)

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

@ 16 pots/m²

$$\text{Running cost per pot} = \frac{131.8}{16} = 8.2 \text{ p/pot}$$

- c. S.D. @ 2000 lux for 3 weeks at intermediate spacing (16 pots/m²)
 plus 6 weeks at final spacing (11.5 pots/m²)

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

$$\frac{0.44 \text{ kW} \times 11 \text{ hrs} \times 21 \text{ days} \times 7.78 \text{ p/kW hr}}{14 \text{ m}^2} = 56.5 \text{ p/m}^2$$

@ 16 pots/m²

$$\text{cost per pot} = \frac{56.5}{16} = 3.5 \text{ p/pot}$$

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

@ 11.5 pots/m²

$$\text{cost per pot} = \frac{113}{11.5} = 9.8 \text{ p/pot}$$

$$\text{Total Running Cost} = 3.5 + 9.8 = 13.3 \text{ p/pot}$$

C. Overall cost of treatment

Trial 1. Bright Golden Anne

	Capital p/pot	Running p/pot	Total p/pot
a. 5000 lux for first 2 weeks of S.D.	3.4	5.5	8.9
b. 5000 lux for first 3 weeks of S.D.	5.0	8.2	13.2
c. 2000 lux throughout S.D.	8.8	13.3	22.1

Trial 2. Yoder varieties

A. Capital cost

- a. L.D. 5000 lux for 1 week at initial spacing (41 pots/m²)

1 m² will service 13 crops (if fixed) at 41 pots/m² = 533 pots

$$\text{Capital cost} = \frac{717}{533} = 1.3 \text{ p/pot}$$

Note: if mobile lights or benches are used then 1 m² will service 26 crops with resultant capital cost of 0.7 p/pot

- b. S.D. @ 5000 lux for 3 weeks, two weeks of which are at intermediate spacing (24 pots/m²)

with a further week at final spacing (12.5 pots/m²)

at intermediate 1 m² will service 13 crops at 24 pots/m² = 312 pots

$$\text{Capital cost} = \frac{717}{312} = 2.3 \text{ p/pot}$$

at final spacing 1 m² will service 26 crops (if mobile) at 12.5 pots/m² = 325 pots

$$\text{Capital cost} = \frac{717}{325} = 2.2 \text{ p/pot}$$

$$\text{Total Capital Cost} = 2.3p + 2.2p = 4.5 \text{ p/pot}$$

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

[@ 5000 lux for 3 weeks at intermediate spacing 18 pots/m²]

at intermediate spacing 1 m² will service 9 crops at 18 pots/m² = 162 pots

$$\text{Capital cost} = \frac{717}{162} = 4.4 \text{ p/pot}$$

- c. S.D. @ 2000 lux throughout for 2 weeks at intermediate spacing (24 pots/m²)
 for 6 weeks at final spacing (12.5 pots/m²)

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

at intermediate spacing 1 m² will service 13 crops at 24 pots/m² = 312 pots

$$\text{Capital cost} = \frac{307}{312} = 1.0 \text{ p/pot}$$

at final spacing 1 m² will service 4 crops at 12.5 pots/m² = 50 pots

$$\text{Capital cost} = \frac{307}{50} = 6.1 \text{ p/pot}$$

$$\text{Total Capital Cost} = 1.0 + 6.1 = 7.1 \text{ p/pot}$$

B. Running cost

- a. L.D. @ 5000 lux for 1 week 41 pots/m²

17 hrs Standard 7.78 p/kW hr
 7 hrs Off-Peak 2.61 p/kW hr

$$\frac{0.44 \text{ kW} \times 17 \text{ hrs} \times 7 \text{ days} \times 7.78 \text{ p/kW hr}}{6 \text{ m}^2} = 67.9 \text{ p/m}^2$$

$$+ \frac{0.44 \text{ kW} \times 7 \text{ hrs} \times 7 \text{ days} \times 2.61 \text{ p/kW hr}}{6 \text{ m}^2} = 9.4 \text{ p/m}^2$$

$$= 67.9 + 9.4$$

$$= 77.3 \text{ p/m}^2$$

@ 41 pots/m² at initial spacing for 1 week

$$\text{Running cost per pot} = \frac{77.3}{41} = 1.9 \text{ p/pot}$$

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

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

@ 24 pots/m² at intermediate spacing for 2 weeks

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

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

@ 12.5 pots/m² at final spacing for 1 week

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

$$\text{Total Running Cost} = 3.7 + 3.5 = 7.2 \text{ p/pot}$$

Alternatively:

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

@ 18 pots/m² at intermediate spacing for 3 weeks

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

c. S.D. @ 2000 lux throughout 2 weeks at 24 pots/m²

plus 6 weeks at 12.5 pots/m²

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

@ 24 pots/m² at intermediate spacing for 2 weeks

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

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

@ 12.5 pots/m² at final spacing for 6 weeks

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

$$\text{Total Running Cost} = 1.6 \text{ p} + 9.0 \text{ p} = 10.6 \text{ p/pot}$$

C. Overall cost of treatment

Trial 2. 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/m ² and 1 week at 12.5 pots/m ²	4.5	7.2	11.7
Alternatively: 5000 lux for first 3 weeks of S.D. at 18 pots/m ²	4.4	7.3	11.7
b. 2000 lux throughout S.D. 2 weeks at 24 pots/m ² and 6 weeks at 12.5 pots/m ²	7.1	10.6	17.7

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

	Capital	Running	Total
a. plus 5000 lux for first 3 weeks of S.D. 2 weeks at 24 pots/m ² and 1 week at 12.5 pots/m ²	1.3+4.5	1.9+7.2	14.9
Alternatively: plus 5000 lux for first 3 weeks of S.D. at 18 pots/m ²	1.3+4.4	1.9+7.3	14.9
b. plus 2000 lux throughout S.D. 2 weeks at 24 pots/m ² and 6 weeks at 12.5 pots/m ²	1.3+7.1	1.9+10.6	20.9

The additional total cost of lighting for 1 week in long days at 5000 lux is 3.2 p per pot. This additional cost must be set against the probable requirement of an additional week of long days where supplementary lighting is not used. The cost benefit can only be effectively calculated on individual production areas.

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

APPENDIX VII.

Photographic records.

Plate 1.

Trial 1. *Bright Golden Anne*

Effect of short day supplementary lighting treatments on winter quality.



A

B

C

D

Treatments from left to right are as follows:

- A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first two weeks of short days.
- C. Supplementary lighting at 5000 lux during the first three weeks of short days.
- D. Supplementary lighting at 2000 lux throughout short days.

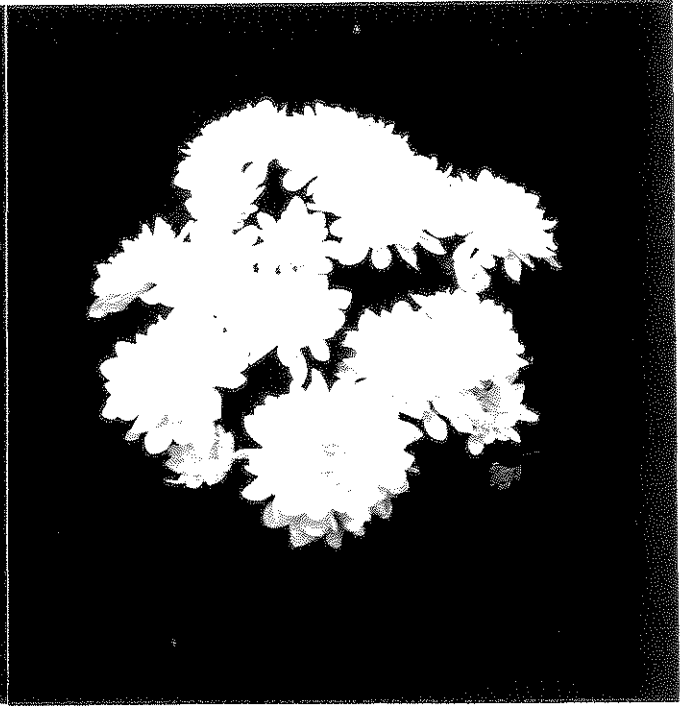
Plate 2.

Trial 1. *Bright Golden Anne*

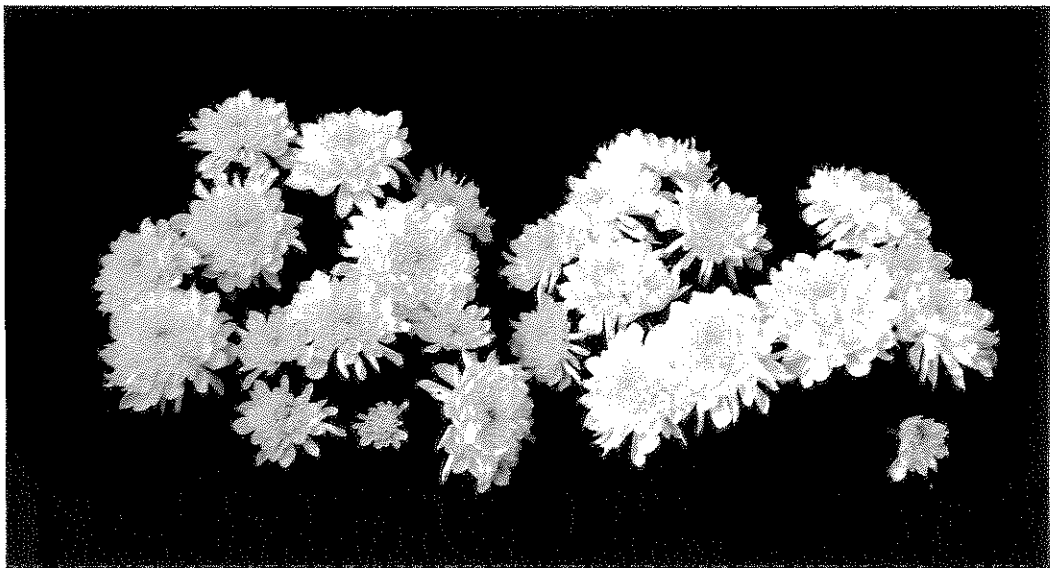
Shelf life assessment stages



Stage 1. Main flowers fully open



Stage 2. Partial deterioration

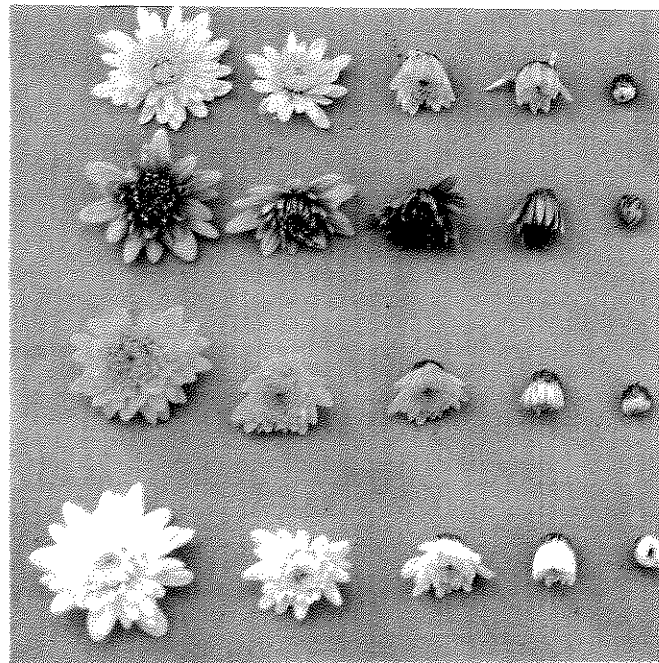


Stage 3. Complete deterioration

Plate 3.

Trial 2. Yoder varieties

a. Assessment bud stages as defined by Cockshull and Hughes (1972).



Dark Yellow Boaldi

Charm

Yuba

Surf

Bud stage 7 6 5 4 3

Plate 4.

Trial 2. Yoder varieties

b. Shelf life stages used for assessment (Charm)



Stage 1.
Main flowers fully open

Stage 2.
Partial deterioration



Stage 3.
Complete deterioration

Plate 7.

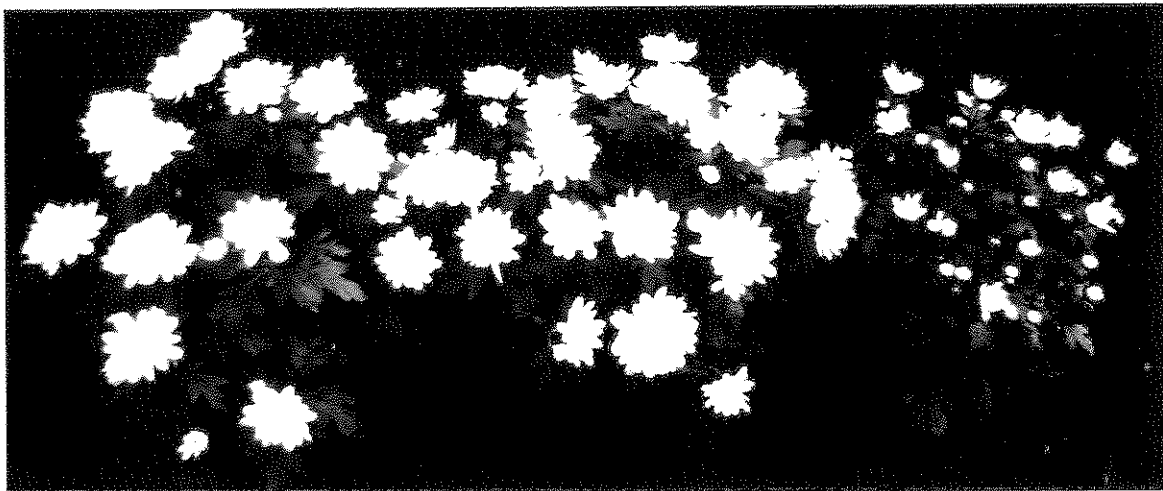
Trial 2. Yoder varieties

Effect of L.D. and S.D. lighting treatments on winter production.

Variety: *Surf* (week 40/41)



S.D. A B C
L.D. UNLIT. No supplementary lighting. 3 weeks of propagation.



S.D. A B C
L.D. LIT. Supplementary lighting at 5000 lux during second week of propagation.
 2 weeks of propagation

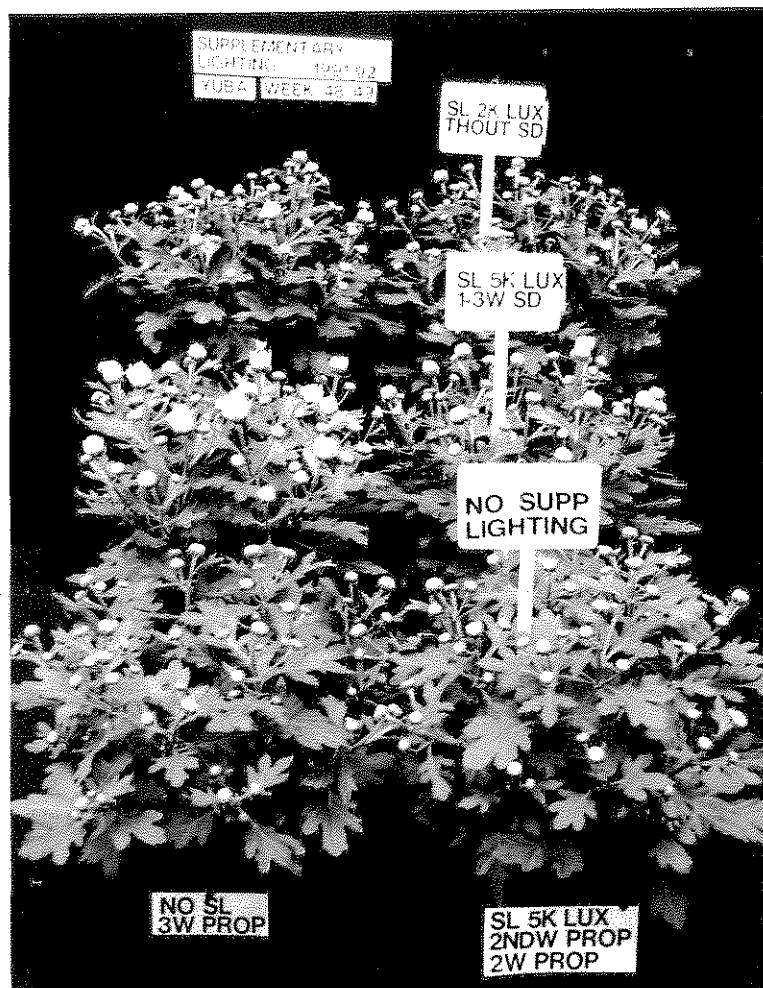
- S.D. A. No supplementary lighting.
- B. Supplementary lighting at 5000 lux during the first three weeks of short days.
- C. Supplementary lighting at 2000 lux throughout short days.

Plate 9.

Trial 2. Yoder varieties

Effect of L.D. and S.D. lighting treatments on winter production.

a. *Yuba* (week 48/49)



L.D. UNLIT

L.D. LIT

L.D. UNLIT No supplementary lighting. 3 weeks of propagation.

L.D. LIT Supplementary lighting at 5000 lux during second week of propagation. 2 weeks of propagation.

S.D. A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

C. Supplementary lighting at 2000 lux throughout short days.

Plate 10.

Trial 2. Yoder varieties

Effect of L.D. and S.D. lighting treatments on winter production.

b. *Dark Yellow Boaldi* (week 48/49)



L.D. UNLIT

L.D. LIT

L.D. UNLIT No supplementary lighting. 3 weeks of propagation.

L.D. LIT Supplementary lighting at 5000 lux during second week of propagation. 2 weeks of propagation.

S.D. A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

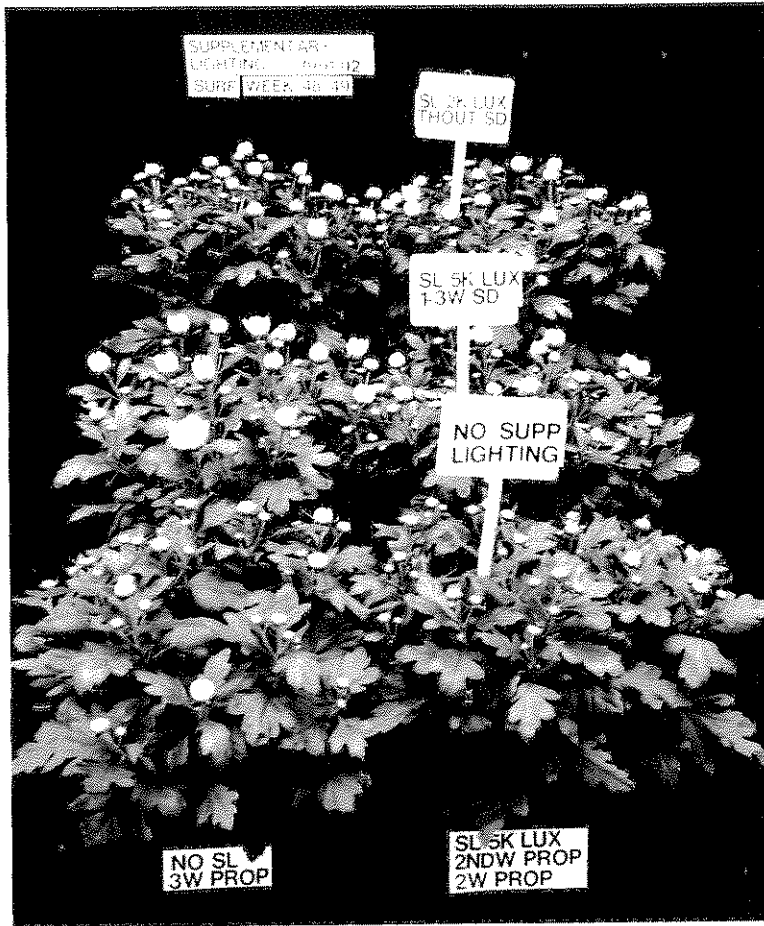
C. Supplementary lighting at 2000 lux throughout short days.

Plate 11.

Trial 2. Yoder varieties

Effect of L.D. and S.D. lighting treatments on winter production.

c. Surf (week 48/49)



L.D. UNLIT

L.D. LIT

L.D. UNLIT No supplementary lighting. 3 weeks of propagation.

L.D. LIT Supplementary lighting at 5000 lux during second week of propagation. 2 weeks of propagation.

S.D. A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

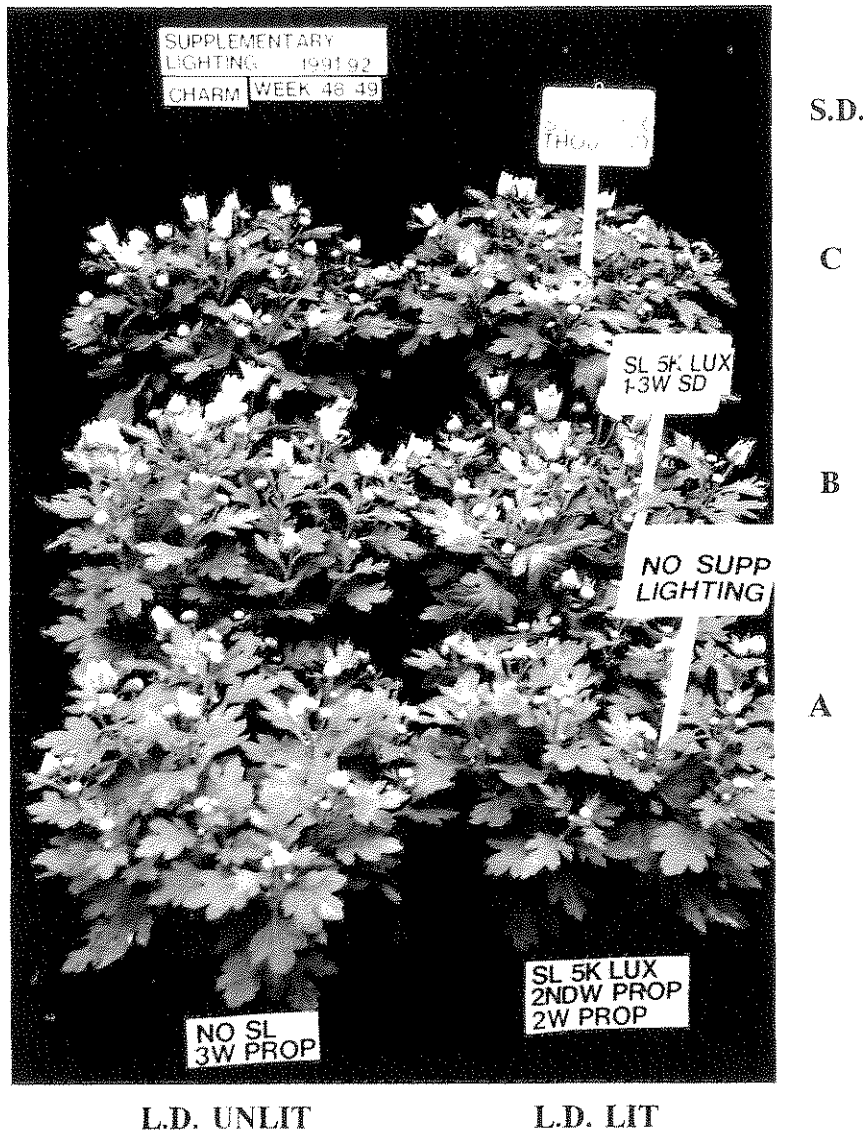
C. Supplementary lighting at 2000 lux throughout short days.

Plate 12.

Trial 2. Yoder varieties

Effect of L.D. and S.D. lighting treatments on winter production.

d. Charm (week 48/49)



L.D. UNLIT No supplementary lighting. 3 weeks of propagation.

L.D. LIT Supplementary lighting at 5000 lux during second week of propagation. 2 weeks of propagation.

S.D. A. No supplementary lighting.

B. Supplementary lighting at 5000 lux during the first three weeks of short days.

C. Supplementary lighting at 2000 lux throughout short days.

APPENDIX VIII.

Solar radiation measurements at HRI Efford during the period October 1991 - February 1992.

Month	Week No.	Radiation MJ m ⁻² d ⁻¹	30 Year average	Percentage difference +/-
October	40	7.93	8.8	- 10
	41	5.37	7.5	- 28
	42	6.24	7.0	- 11
	43	3.33	5.8	- 43
	44	3.28	5.0	- 34
November	45	4.72	4.4	+ 7
	46	3.32	3.7	- 10
	47	2.75	3.3	- 16
	48	1.92	2.9	- 33
December	49	1.85	2.6	- 29
	50	3.09	2.5	+ 23
	51	1.83	2.3	- 20
	52	2.21	2.4	- 8
January	1	1.62	2.6	- 37
	2	3.31	2.7	+ 22
	3	2.01	2.8	- 28
	4	3.18	3.4	- 7
	5	4.19	3.8	+ 10
February	6	4.13	4.4	- 6
	7	4.76	4.9	- 3
	8	5.36	5.4	- 1
	9	5.38	7.4	- 37

APPENDIX X.

References

Cockshull, K.E. and Hughes, A.P: 1972. Flower formation in *Chrysanthemum morifolium*: the influence of light level. *J. Hort. Sci.*, **47**, 113.

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APPENDIX IX.

Copy of Contract Terms and Conditions and Schedules

INSTITUTE OF HORTICULTURAL RESEARCH, LITTLEHAMPTON

MEMORANDUM

TO: M. Leatherland
c.c. Divisional Head (without enclosure)
Station Administrator/EHS Station Head

FROM: R K Arthur

DATE: July 17, 1990

SUBJECT: HDC Contracts

=====
The HDC is now starting to send out formal contracts for signature on behalf of the BSHR and I attach a copy of the following contract:

C102 PC13(b) Supplementary lighting - pot chrysanthemums

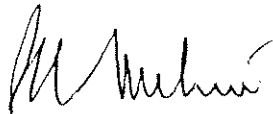
Before the BSHR undertakes this legal commitment I should be grateful for your written confirmation that the contract terms are acceptable to the BSHR, and that the resources needed to carry out the work can be made available within the contract price.

As there are so many of these HDC contracts to be considered it is necessary to introduce a degree of uniformity (as the HDC itself recognized when seeking proposals in a standard format). Would you mind therefore filling in and returning to me the attached form please, even if some of the details are not relevant to your contract.

On the basis of these forms the contracts will then be signed or altered as necessary and I will let you know as soon as the BSHR is formally committed to carrying out the work. I appreciate that some contracts have already started on the basis of a letter of intent from HDC.

One claim will be sent from Littlehampton each quarter to HDC for monies due under all BSHR contracts with HDC. If therefore there is any reason why the customer should not be charged in accordance with the schedule in para 11 of the attached contract please write both to me and your Station Administrator/EHS Station Head.

Finally this contract has been given number C102 on the commercial database and it would help if you will use this number in internal correspondence (or even the HDC number would be better than nothing!).



RKA/ps

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

PROPOSAL

1. TITLE OF PROJECT:

Contract No: PC/13b

SUPPLEMENTARY LIGHTING FOR POT CHRYSANTHEMUMS.

2. BACKGROUND AND COMMERCIAL OBJECTIVE

In work carried out at the Lee Valley EHS from 1987 to 1989 supplementary lighting during the first two weeks of short days improved uniformity and bud count and reduced production time by up to eight days. From other observations it would seem that the quality of natural light received in the third to fifth week of short days is even more important than that received in weeks one and two. It would therefore be beneficial to study the effect of supplementary lighting during this period. It has been suggested that lighting during the last two weeks of short days could be used to improve the shelf life of some varieties. The concept of lighting at a relatively low light intensity through the whole life of the crop is also being considered by some growers.

3. POTENTIAL BENEFIT TO THE INDUSTRY

Many growers already light the crop during the first two weeks of long days.

If lighting were found to be more beneficial in weeks 3 and 4 this could be used as an alternative but would require the provision of extra lights to allow for spacing out. This might amount to an increase in lighting cost of 60%. The alternative might be to use lights continuously from week 1 to week 4. This would require an increase of 160%.

A costing in 1989 suggested that lighting for only two weeks gave a net benefit of £960/acre/year. This was based on increased throughput but no additional quality. A similar increase in throughput would not justify additional lighting at a wider spacing but an improvement in quality and or slightly higher throughput might tip the balance.

4. SCIENTIFIC / TECHNICAL TARGET OF THE WORK

A programme of work is needed, preferably over two seasons to investigate different combinations of lighting and spacing. The first year would study the basic principles picking reasonably commercial combinations. Promising treatments could be expanded

and reassessed in year 2. A second year would also give more flexibility in the number of varieties examined.

5. CLOSELEY RELATED WORK - COMPLETED OR IN PROGRESS

The work conducted previously at Lee Valley EHS has provided a sound basis for future trials giving indications of suitable light levels and experimental techniques.

6. DESCRIPTION OF THE WORK

The following description has been divided into three trials but there may be some overlap between them in practice. It covers the proposal for 1990/91 only.

TRIAL 1.

Treatments.

1. Unlit.
2. Lit weeks 1-2 at 25 pots/m
3. Lit weeks 1-3, spacing to be decided.
4. Lit weeks 1-4, 25 pots/m in weeks 1 and 2, 16 in weeks 3 and 4.
5. Lit weeks 3-4, 25 pots/m in weeks 1 and 2, 16 in weeks 3 and 4.
6. Lit throughout at 2 K Lux. Normal spacing.

All treatments lit at 5 k Lux except treatment 6. The variety Bright Golden Ann would be used on 4 sticking dates with two replicates at each sticking date.

TRIAL 2.

Treatments.

1. Unlit
2. Lit weeks 3-4
3. Lit weeks 1-4.

Up to 8 varieties. This could be 8 varieties or two replicates of 4 varieties. There would be two sticking dates. This would either give replication in time or would enable twice the number of varieties to be screened.

TRIAL 3.

Treatments

1. Unlit.
 2. Lit weeks 1-4 and last two weeks.
 3. Lit last two weeks only.
- 8 Varieties or two replicates of 4 varieties.
One sticking date.

RECORDS

The records taken would include:

1. Total number of buds and flowers.
2. Stage of development of most advanced bud/flower.
3. Height and spread.
4. Shelf life (from all trials).

7. COMMENCEMENT DATE AND DURATION

October 1990 to March 1991.

October 1991 to March 1992.

8. STAFF RESPONSIBILITIES

Project Leader: M Leatherland

Other staff: Dr F A Langton, Littlehampton

9. LOCATION

Efford EHS

10. COSTS

£20,000 per annum for two years.

11. PAYMENT

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

QUARTER/YEAR	1990	1991	1992
1	- - -		
2	- - -	10,000	10,000
3		- - -	- - -
4	10,000	10,000	- - -

CONTRACT C102

Date: July 1990

HDC PC13(b). Supplementary Lighting - Pot Chrysanthemums

1. I confirm that the terms of this contract are acceptable to the BSHR.
2. The following resources will be needed and have been confirmed with the appropriate department.

a. Staff Time - existing

HAO Time	20 days
SO Time	5 days
ASO Time	35 days
Industrial	45 days

b. No new staff required.

c. Facilities

5 compartments of E-Block
 2 compartments of K-Block with lighting rigs

d. Miscellaneous resources

Horticultural sundries £500

3. Breakdown of Expenditure

	1990/91
Staff Costs	£19315
Recruitment	-
Travel	£ 200
A & E	-
Lab Supplies	-
Technical Costs	£ 500

Signed *M. J. ...*
 Project Leader