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CONTRACT REPORT

No PC12/88
Interrupted Lighting Schedules
for AYR SPRAY Chrysanthemum
Cultivars

PRINCIPAL WORKERS

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Authentication

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

R F Clements

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CONTENTS

SUMMARY

On two occasions winter flowerings of a range of commercial varieties were grown using various short day durations prior to interruption. From visual assessments it was possible to identify the most appropriate number of days under the light conditions prevailing. Four groups were identified according to their speed of bud initiation in short days.

More detailed data was collected by Dr F A Langton at IHR Littlehampton on a smaller range of 'marker' varieties also included in this work. This enables predictions of readiness for interruption to be made according to light data. By grouping a wider range of varieties with their appropriate 'marker' it is now possible to give light based predictions for a wider range of varieties than was originally possible.

A further comparison was made between treatments in this work and with a trial funded by MAFF in which the same range of varieties was grown giving an extra 10 days in the form of an addition to the initial long day period rather than as an interruption. This showed that for all except two of the varieties it was preferable to give the extra 10 days in the form of an interruption.

A predictive service is now available through the ADAS glasshouse unit at Chichester and the results of this work and the IHR work have been incorporated to improve the accuracy of that service. Growers have had the opportunity to see and comment on both trials.

Introduction

Work on interrupted lighting has been carried out jointly under H.D.C. project PC/12 by Dr A Langton at IHR Littlehampton and by M Leatherland at Efford EHS. This report is for Efford EHS only.

The background to the work on interrupted lighting and an explanation of the technique is covered in the report for IHR Littlehampton. The trials at Littlehampton enabled predictive tables to be produced relating light levels during the short day period to speed of initiation for six "key" varieties. The trials at Efford complement this work by growing crops in a commercial situation where quality aspects can be considered, and by extending the range of varieties examined with the intention of grouping them accordingly to their speed of response to simplify crop programming.

The efford trials have further served as demonstrations to the industry of the effects of interruption and every opportunity has been taken to ensure growers have had access to them and to parallel trials funded by MAFF.

Materials and Methods

Site

The trials were carried out at Efford EHS Lymington, Hampshire in part of a 1000 m^2 widespan house typical of the sort of glasshouse used by the industry. Heating is by hot water pipes around each bed and the house is equipped with an overhead blackout screen of modern materials (EV1 + LS11).

Treatments

The trial was performed on two separate occasions.

Planting 1. (11 Dec 1986)

Varieties:	Delta	Pink Gin
	Snowdon (White)	Texas
	Snapper (Pink)	Robeam
	Snapper (pale Salmon)	Daymark
	Bronze Rosado	

All varieties were given 28 long days followed by a range of short day periods then returned to long days for an interruption of 10 days.
Number of short days: 12, 15, 18, 21, 24, 27

Planting 2. (16 Nov 1987)

Varieties:	Bronze Rosado	Robeam
	Cassa	Snapper (Pink)
	Daymark	Snowdon
	Delta	Texas
	Snapper (pale Salmon)	Fresco (White)
	Pink Gin	

As for planting 1, all varieties were given 28 initial long days followed by a range of short day periods before an interruption of 10 days.

Number of short days: 9, 12, 15, 18, 21.

This second trial used briefer short day periods as a result of experience gained from the first trial and, by reducing the number of short day treatments, enabled more varieties to be grown.

Design

In order to examine the maximum number of varieties trials were carried out without conventional replication. In both cases the trial occupied 3 beds, each 17m in length with an area of 26 m^2. Plot size was 60 plants planted at 12.5 cm centres, with three complete rows of 12 plants recorded. Treatments involving different durations of short days were allocated to half beds and varieties were randomly allocated within these areas.

Records and Scoring

Trial plants within each plot were scored at the bud-colour stage for percentage flower initiation during the short-day period by Dr. A Langton of IHR, Littlehampton. A plant judged to have been completely initiated (terminal and 7 laterals) prior to interruption was given a percentage score of 100. Such plants have a 'terminal' spray habit and a 'normal' number of leaves on the main stem. A plant which had initiated the terminal bud and 3 laterals, for example, was given a score of 50. Such a plant has the classical 'double-decker' habit with delayed flowering, leafy lower laterals overgrowing the more advanced upper lateral flowers. A compounded plant which had initiated only the terminal flowers was given a percentage score of 12.5; such plants were distinguished from 'prematurely-budded' plants (which were excluded from analysis) on the basis of leaf number on the main stem. Plants which had a 'terminal' spray habit but which were showing flowering delay were judged to have initiated no flowers prior to interruption (score of 0) but to have initiated flowers when short days re-commenced. Such plants were generally weak growing and to be found in plots given the briefer periods of short days. Plant scores were averaged to give plot scores.

Scoring of plants for percentage initiation was possible in trial 1 even though a fire in the glasshouse on 4th February badly scorched the plants.

Plants in trials 1 and 2 were also scored at final harvest for:

1. Pedicel length of the second lateral (cm)
2. Stem length
3. Bud count ('useful' buds only counted)

Plants in trial 2 were additionally scored for:

4. Final gradeout
5. Total number of days from planting to harvest

Plants in trial 2 were also compared with others (MAFF-funded) which had been planted at the same time, given no interruption, but given a long-day period extended by 10 days. The side-by-side nature of these trials and lack of replication precluded statistical analysis.

Records of daily light integral were kept during the trials to enable comparison with predictions made on the basis of the Littlehampton work.

Culture

In both trials material was bought in from commercial suppliers. For planting two it had originally been intended to supply Efford raised cuttings and stock plants had been cultivated for that purpose. Unfortunately the gales of 16th October destroyed the planting material and cuttings again had to be purchased from outside. This delayed planting by approximately 4 weeks.

Cuttings were rooted at Efford in 4.3cm peat blocks and planted out into the growing house at the usual stage. Average temperatures during the initial short day period were 16^{0}C for planting 1 and 15.5-16^{0}C for planting 2. It was not possible to grow at the 17^{0}C originally planned due to missing glass as a result of the gale damage. Alar treatments were applied to some varieties in planting 2.

9.12.87: Robeam and Texas 625 ppm
Daymark at 312 ppm
18.12.87: Robeam at 625 ppm

Pest control was by sprays of Pentac for red spider mite with Diazatol and Pirimor for aphids.

Results & Discussion

Planting 1

On the 3 February as the crop was reaching maturity it was seen by a group of chrysanthemum growers who were able to make their own assessments of treatments. The following night a fire destroyed the blackout screen over the crop and badly scorched the trial. Although it was not possible to take the crop to final harvest the plants were sufficiently mature for an assessment of flower initiation to take place. The progression of flower initiation with time is shown in Table 1.

Table 1. Percentage of plants fully committed to flower at the start of interruption (Dr F A Langton)

Cultivar	Number of short days before interruption					
	12	15	18	21	24	27
Delta	12.5	62.9	91.2	100	100	100
Snowdon	57.6	96.6	100	100	100	100
Snapper (pink)	57.1	96.4	100	100	100	100
Snapper (pale salmon) *	-	-	-	-	-	-
Bronze Rosado	78.6	97.0	100	100	100	100
Pink Gin	69.7	97.2	100	100	100	100
Texas	3.3	60.6	100	100	100	100
Robeam	84.8	100	100	100	100	100
Daymark	96.8	100	100	100	100	100

* Too few plants for accurate assessments.

Clear differences in speed of initiation were shown; a tentative grouping of cultivars by response type is as follows:

Fast response:-	Daymark, Robeam
Medium response:-	Snapper, Snowdon, Pink Gin, Bronze Rosado
Slow response:-	Texas, Delta

There was some evidence that an early interruption of Bronze Rosado (but after buds had initiated) gave an uncharacteristic and deleterious bracting in the centre of last-formed inflorescences.

Although it was not possible to assess harvest quality, a useful measure of the effect of interruption was gained by measuring pedicel length on those plants which survived the fire. The results (Table 2) indicate that interruptions made 'late', i.e. after 15-18 days when buds were fully initiated, give shorter pedicels. Thus, if pedicel extension to improve spray form is judged to be a potential benefit of interruption, late interruptions are to be avoided. Some cultivars, e.g. Texas, appear less responsive to pedicel stretch than others.

Table 2. Planting 1. Pedicel length of 2nd lateral (cm)
(terminal sprays only)

Cultivar	Number of short days before interruption					
	12	15	18	21	24	27
Delta	9.5*	8.6	8.4	7.6*	7.8	6.1
Snowdon	6.3	9.1*	7.9	5.7	8.2	7.0
Snapper (pink)	12.4	12.7*	10.4	9.2	9.1	9.7
Snapper (Pale Salmon)	13.9*	12.7*	11.9	10.0	11.2	11.5
Rosado	12.5	13.1	11.4	8.6	8.7	10.3
Pink Gin	9.9	9.6*	10.3	8.6	7.3	6.1
Texas	5.5	5.0	5.2	-	5.3	5.5*
Robeam	13.0	14.1	10.9	8.5	9.6	10.4
Daymark	9.5	8.6*	8.4	7.6	7.8	6.1
Average (all cvs)	10.3	10.4	9.4	7.9 +	8.3	8.1

* Reduced number of plants due to fire damage.

\+ A value of 5.3 included for Texas to enable comparisons to be made.

Table 3. Planting 1. Height at harvest (cm)

Cultivar	Number of short days before interruption					
	12	15	18	21	24	27
Delta	89*	85	81	76*	81	74
Snowdon	95	101*	96	89	94	89
Snapper (Pink)	86	91	89	86	81	84
Snapper (Pale Salmon)	82*	82*	83	77	79	84
Rosado	94	96	95	96	89	93
Pink Gin	102	99*	103	90	92	91
Texas	104	101	109	-	81	74*
Robeam	101	91	98	86	93	89
Daymark	89	85*	81	76	81	74
Average (all cvs)	94	92	93	85	86	84

* Assessments made on reduced number of plants

Table 3 shows plant heights at harvest. The differences between treatments cannot be explained simply on the basis of an effect on pedicel length. Plants from late interruptions would not be expected to have fewer leaves than those interrupted after 15-18 days, inferring that late interruption has a reduced effect in increasing internode length.

It is difficult to fairly assess the number of 'useful' buds in a crop, especially one that is badly scorched. Nevertheless, data are presented in Table 4. The differences are small but indicate that early interruptions not only give compounded plants, but also depress the number of flowers. The reasons for this, if significant, are obscure since one might expect compounded plants to have more (but smaller) flowers.

Table 4. Planting 1. Bud count at harvest **

Cultivar	Number of short days before interruption					
	12	15	18	21	24	27
Delta	4.0*	5.6*	7.3	6.8*	7.9	7.1
Snowdon	7.0	7.5*	9.4	8.2	8.6	8.3
Snapper (Pink)	7.1	6.9*	6.8	7.5	8.0	6.3
Snapper (Pale Salmon)	7.1*	6.9*	6.8	7.5	8.0	6.3
Rosado	7.2	9.9	9.1	11.5	8.2	8.8
Pink Gin	7.2	7.8*	9.6	9.1	7.8	7.4
Texas	6.6	7.4	7.2	-	9.4	9.1*
Robeam	7.2	9.9	9.1	11.5	8.2	8.8
Daymark	8.1	7.6*	9.4	13.6	10.2	9.6
Average (all cvs)	6.8	7.7	8.3	9.3+	8.5	8.0

** Number of useful buds only

* Assessments made on reduced number of plants

+ A value of 8.3 included for Texas to enable comparisons to be made

Planting 2

Visual assessments of percentage flower initiation with time are given in Tables 5a and b. It was observed that larger plants tended to be more advanced in budding than smaller plants; Table 5a is based on all the plants within the trial plots whilst 5b gives data only for those plants with a stem length greater than the mean for the whole plot. The slightly faster flowering for the large plants of cultivars such as Snowdon may be attributable to the effect of greater 'maturity' when short days began or to 'successful' competition against smaller plants.

Table 5a. Planting 2: Percentage flower bud initiation at the start of interruption - all plants per plot (Dr. F A Langton)

	Number of short days before interruption				
Cultivar	9	12	15	18	21
Robeam	12.1	35.3	59.8	100	100
Snapper	28.3	53.6	88.8	95.8	100
Delta	7.6	-	15.7	24.6	72.4
Pale Salmon Snapper	18.8	39.6	73.6	97.6	96.2
White Fresco	0.5	9.6	14.1	35.5	67.5
Daymark	13.9	38.5	85.1	100	100
Snowdon	9.3	13.9	41.3	83.3	97.5
Cassa	19.3	39.4	62.5	79.8	100
Bronze Rosado	23.6	60.2	74.6	98.2	97.2
Pink Gin	14.0	30.6	67.4	100	100
Texas	3.6	14.0	25.0	46.4	84.0

Table 5b. Plant 2: Percentage flower bud initiation at the start of interruption - largest plants per plot (Dr F A Langton)

Cultivar	Number of short days before interruption				
	9	12	15	18	21
Robeam	13.1	43.8	65.1	100	100
Snapper	25.0	64.4	94.2	100	100
Delta	8.3	-	15.1	23.9	73.1
Pale Salmon Snapper	18.8	42.9	79.2	99.3	100
White Fresco	2.6	13.2	17.9	48.0	93.8
Daymark	13.2	48.8	91.8	100	100
Snowdon	11.8	19.4	59.0	91.5	100
Cassa	16.3	49.3	61.0	87.5	100
Bronze Rosado	24.3	82.1	88.4	96.9	100
Pink Gin	16.3	38.7	74.3	100	100
Texas	2.4	17.1	34.6	61.8	92.5

Plotting the progression of flower initiation against time for each cultivar based on all plants per plot (Figures 1-4) enabled response groupings to be determined. Note that extrapolations are made to give responses intermediate between the numbers of short days chosen in the trial, and to exclude the effects of occasional vegetative lower laterals in Snapper cultivars having a disproportionate effect.

Fast response:-	Daymark*, Snapper*
Fast/Medium response:-	Pink Gin*, Pale Salmon Snapper
Intermediate response:-	Snowdon*, Robeam, Cassa and Bronze Rosado
Slow response:-	Delta*, Texas and White Fresco

The results for Snowdon may be atypical since cuttings of an aberrant 'Kenya' clone were delivered. In general the groupings for the two trials agree reasonably well. In practice it may be sufficient to combine the two intermediate groupings.

Cultivars with an asterisk are those for which detailed light-integral relationships have been calculated at Littlehampton. It is possible on the basis of light integral measurements taken at Efford during the trial (Appendix 3) to compare actual performance at Efford with predicted performance using Littlehampton data (making no allowance for slightly lower temperatures in the Efford trial). This comparison is given in Table 6. The predictions over-estimate the time taken to fully initiate Snapper (4 days) and Pink Gin (2 days), are correct for Daymark and Snowdon, and underestimate Delta (1 day). Overall. the correspondence is encouraging and lead us to believe that the combination of light-integral monitoring and cultivar grouping could provide a workable basis for estimating when interruptions can safely begin.

Table 6. Planting 2: Number of short days required for full initiation.

Cultivar	Number short days (Efford Trial)	Predicted number at 17^{0}C (Littlehampton data) Upper safety limit	Average daily light integral (inside, PAR MJ m^{-2})
Snapper	16	20	0.43
Delta	22	21	0.45
Daymark	16	16	0.40
Snowdon	19*	19	0.42
Pink Gin	17	19	0.42

* Kenya clone

For both pedicel length (Table 7) and stem length (Table 8) there is an apparent trend towards reduced extension with increase in the duration of the short day period. It should be remembered, however, that the shorter durations of short days are associated with incomplete flower initiation and compound sprays.

Table 7. Planting 2. Pedicel length (cm)

Cultivar	Number of short days before interruption				
	9	12	15	18	21
Delta	6.8	7.6	6.4	10.1	6.2
Snowdon	7.2	6.8	4.4	5.0	4.2
Snapper (Pink)	15.3	17.1	15.9	15.8	16.5
Snapper (Pale Salmon)	15.5	14.5	12.1	12.1	11.4
Rosado	11.2	9.4	10.6	9.4	8.6
Pink Gin	10.4	8.2	6.9	7.7	8.0
Texas	6.0	6.3	4.0	3.6	3.0
Robeam	10.8	8.1	8.9	8.3	7.7
Daymark	11.9	10.0	8.0	7.6	7.7
Cassa	14.9	13.9	12.1	10.9	11.1
White Fresco	6.1	7.0	4.8	6.7	6.5
Average (all cvs)	10.6	9.9	8.6	8.8	8.3

Table 8. Planting 2. Height at harvest (cm)

Cultivar	Number of short days before interruption				
	9	12	15	18	21
Delta	70	90	77	76	76
Snowdon	77	74	74	75	67
Snapper (Pink)	93	88	93	91	87
Snapper (Pale Salmon)	87	85	83	81	77
Bronze Rosado	88	90	86	84	78
Pink Gin	94	92	90	92	89
Texas	91	94	100	86	85
Robeam	87	84	75	83	77
Daymark	90	92	86	83	92
Cassa	99	92	86	90	95
White Fresco	75	70	68	68	70
Average (all cvs)	86.5	86.5	83.5	82.6	81.2

Tables 9-12 give gradeout data for plots of the second planting. Where cultivars do appear to show differences in overall gradeout (wraps per 1000 stems planted), the best results tend to be associated with the longer durations of short days. These are not late interruptions, however, since the environmental conditions of the trial were such that complete initiation for most cultivars did not occur except in the longer durations of short days. The highest percentages of grade 1 stems tended to be associated with the 15 and 18 short day treatments. Conversely, the highest percentages of make up/waste tended to be associated with the 9 and 12 short day treatments. On the basis of gradeout it appears reasonable to aim for crops which are interrupted immediately flower initiation has been completed.

Table 9. Planting 2. Overall gradeout Wraps/1000 stems planted

Cultivar	Number of short days before interruption				
	9	12	15	18	21
Delta	57.7	46.3	59.4	58.0	57.6
Snowdon*	47.8	41.0	55.2	58.4	61.7
Snapper (Pink)	59.1	62.0	61.7	58.0	60.9
Snapper (Pale Salmon)	57.3	57.6	59.4	62.2	60.3
Bronze Rosado	60.9	58.4	62.0	55.3	57.2
Pink Gin	58.8	56.0	59.4	58.9	62.2
Texas	56.1	64.1	58.2	55.0	60.9
Robeam	67.8	56.3	75.0	77.8	78.4
Daymark	63.0	63.4	70.0	64.4	76.8
Cassa	68.1	52.9	61.7	66.1	71.1
White Fresco	53.0	48.9	50.6	58.8	58.3

Table 10 Planting 2. % sprays in grade I (Efford grades 10 & 13)

Cultivar	Number of short days before interruption				
	9	12	15	18	21
Delta	11.0	5.9	27.8	39.4	19.4
Snowdon	11.8	8.3	24.2	18.8	19.4
Snapper (Pink)	45.7	41.7	36.1	25.0	14.7
Snapper (Pale Salmon)	12.5	17.6	11.8	16.7	22.2
Rosado	25.7	19.4	25.0	11.1	5.6
Pink Gin	25.0	16.7	11.1	20.7	25.0
Texas	30.6	33.3	34.5	25.0	25.8
Robeam	53.3	25.0	57.1	70.4	67.7
Daymark	11.0	5.9	27.8	39.4	19.4
Cassa	50.0	15.6	25.0	47.1	45.7
White Fresco	15.6	17.1	18.2	30.6	22.2

Table 11. % sprays in grade II (Efford grades 16 & 19)

Cultivar	Number of short days before interruption				
	9	12	15	18	21
Delta	72.2	64.7	47.2	39.4	58.3
Snowdon	44.1	47.2	39.4	65.6	66.7
Snapper (Pink)	37.1	36.1	36.1	52.8	79.4
Snapper (Pink Salmon)	62.5	61.8	73.5	80.6	50.0
Bronze Rosado	54.3	50.0	50.0	58.3	86.1
Pink Gin	53.1	63.9	83.3	44.8	63.9
Texas	36.1	45.5	34.5	38.9	54.3
Robeam	30.0	40.6	32.1	22.2	25.8
Daymark	72.2	64.7	47.2	39.4	58.3
Cassa	33.3	56.3	44.4	32.4	37.1
White Fresco	62.5	31.4	54.5	41.7	47.2

Table 12. % make ups/waste (Efford grades 22,25 & waste)

Cultivar	Number of short days before interruption				
	9	12	15	18	21
Delta	16.7	38.2	25.0	21.2	22.2
Snowdon	44.1	41.7	36.4	15.6	16.7
Snapper (Pink)	17.1	22.2	27.8	22.2	5.9
Snapper (Pale Salmon	25.0	23.5	14.7	5.6	27.8
Bronze Rosado	20.0	30.6	25.0	30.6	8.3
Pink Gin	21.9	19.4	5.6	34.5	11.1
Texas	33.3	18.2	31.0	36.1	17.1
Robeam	16.7	34.4	10.7	7.4	6.5
Daymark	16.7	38.2	25.0	21.2	22.2
Cassa	16.7	28.1	30.6	20.6	17.1
White Fresco	21.9	51.4	27.3	27.8	30.6

In general, visual assessment of the plots tended to support the conclusion that early interruptions were detrimental. This was not invariably the case, however. Cassa appeared perfectly acceptable, perhaps preferable, when interrupted early i.e. before full flower initation. The result was a bushy plant with many flowers. It is, of course, common practice in Holland to use split interruptions to induce compounding in cultivar Cassa. The defect in Bronze Rosado of bracts in the centres of inflorescences following early interruptions was not repeated in the second trial.

Of particular interest was the comparison of plots given a 10 day interruption and others (MAFF-funded) where the initial long-day period was extended by 10 days. For ease of comparison, the interrupted treatment most nearly corresponding to complete initiation was chosen. Table 13 shows that interrupted plants tend to be taller even though they can be expected to have fewer leaves on the main stem. They also tend to give better gradeouts (see also Table 14) although this was not true for Delta, Texas and Rosado. Surprisingly, however, they tend to flower up to seven days later. It is generally assumed that the delay in flowering due to interruption will be no longer than the total length of the interruption. This may be untrue or the plants given extra initial long days flower more rapidly as a consequence of their increased 'maturity' at the onset of short days. Alternatively, since the onset of short days was not synchronised in the two trials, the results may reflect differences in the growing environemnts (light levels etc) of the two trials when short days were begun. Until the cause of delay is resolved, however, it remains a possibility that any improvements in quality due to the use of interruption are at the expense of production time over and above the length of the interruption itself.

Table 13. Comparison of the interrupted treatment corresponding to complete initiation and uninterrupted plots given 10 extra initial long days.

Cultivar	Height cm		Days from planting		Wraps (1000 stems planted)	
	int.	+10	int.	+10	int.	+10
Delta	76	67	110	105	58	67
Snapper	93	85	98	93	62	55
Pale Salmon Snapper	81	79	103	96	62	52
Bronze Rosado	84	86	102	98	55	55
Pink Gin	92	81	100	101	59	55
Texas	85	81	110	105	61	63
Robeam	83	70	107	102	78	65
Daymark	86	83	100	95	70	68
Cassa	90	87	100	93	66	64
Average (all cvs.)	85.6	79.9	103.3	98.7	63.4	60.4

Table 14. Comparison of the interrupted treatment corresponding to complete initiation and uninterrupted plots given 10 extra initial long days.

Cultivar	% 10-13		%16-19		%22-Waste	
	int.	+10	int.	+10	int.	+10
Delta	19.4	43.4	58.3	33.3	22.2	23.3
Snapper	36.1	8.6	36.1	57.1	27.8	34.3
Pale Salmon Snapper	16.7	5.6	80.6	58.3	5.6	36.1
Bronze Rosado	11.1	14.3	58.3	51.4	30.6	34.3
Pink Gin	20.7	13.9	44.8	52.8	34.5	33.3
Texas	25.8	29.6	54.3	48.2	17.1	22.2
Robeam	70.4	62.1	22.2	20.7	7.4	17.2
Daymark	50.0	42.4	30.6	39.4	19.4	18.2
Cassa	47.1	29.4	32.4	47.1	20.6	23.5
Average (all cvs.)	33.0	27.7	46.4	45.4	20.6	26.9

Conclusion

This work has provided useful information to enable growers to more accurately assess the correct time for interrupting a wider range of varieties than was previously possible. Growers were given every opportunity to see the trials and the findings have already been incorporated into advisory services available from the ADAS glasshouse unit at Chichester. It was also shown that interruptions in most cases do improve the quality of flowers compared to simply adding an equivalent number of long days to the initial long day period.

The comparison between treatments in this trial and those of a MAFF funded trial should be taken as an indication that ADAS development workers are keen to work with the industry whenever possible.

Acknowledgements

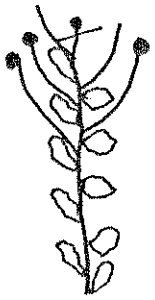
The author would like to express thanks to John Phillips for his guidance on technical matters and to the H.D.C. for funding the work. Thanks are also due to R F Potter and T V Sims at GMAU and particularly to Dr F A Langton of IHR Littlehampton for his assistance with assessing the plots, processing the data and writing this report. And finally, thanks are due to all staff at Efford involved with this trial.

Appendix 1. Flower Forms

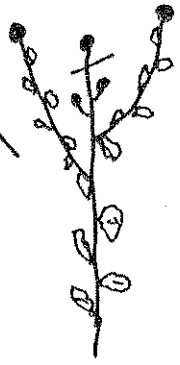
Normal Schedule

Interrupted Schedule

Correct



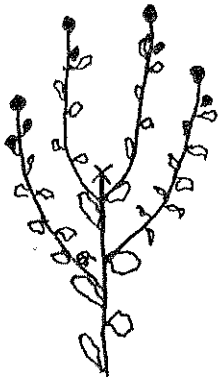
Interruptions too soon



Double-decker spray

Long days

Short days



Compound spray two possible causes:-

1. Premature budding. Breaks normally lower down plant than usual buds occurred in initial long days.

2. Very premature interruption only one bud formed in first short day period. Usually other plants in plot with some double-deckering.

Appendix 2

Light levels from start of short days (inside PAR MJ m^{-2} d^{-1})

Planting 1. S.D. started 8 Jan 1987 (1st long night was 8th Jan)

Date	No.short days	PAR	Running Total	Daily average
9.1.87	1	1.55	1.55	1.55
10	2	0.48	2.03	1.02
11	3	0.86	1.75	0.58
12	4	1.08	2.83	0.71
13	5	1.03	3.86	0.77
14	6	0.27	4.13	0.69
15	7	0.38	4.51	0.64
16	8	0.62	5.13	0.64
17	9	0.23	5.36	0.60
18	10	0.19	5.55	0.55
19	11	0.30	5.85	0.53
20	12	0.53	6.38	0.53
21	13	0.30	6.68	0.51
22	14	0.39	7.07	0.51
23	15	0.58	7.65	0.51
24	16	0.30	7.95	0.50
25	17	0.40	8.35	0.49
26	18	0.72	9.07	0.50
27	19	0.71	9.78	0.51
28	20	1.20	10.98	0.54
29	21	1.66	12.64	0.60
30	22	1.78	14.42	0.66
31	23	1.62	16.04	0.70
1.2.87	24	1.42	17.46	0.73
2	25	0.30	17.76	0.71
3	26	0.93	18.69	0.72
4	27	0.57	19.26	0.71

Appendix 3

Light levels from start of short days (inside PAR MJ m^{-2} d^{-1})

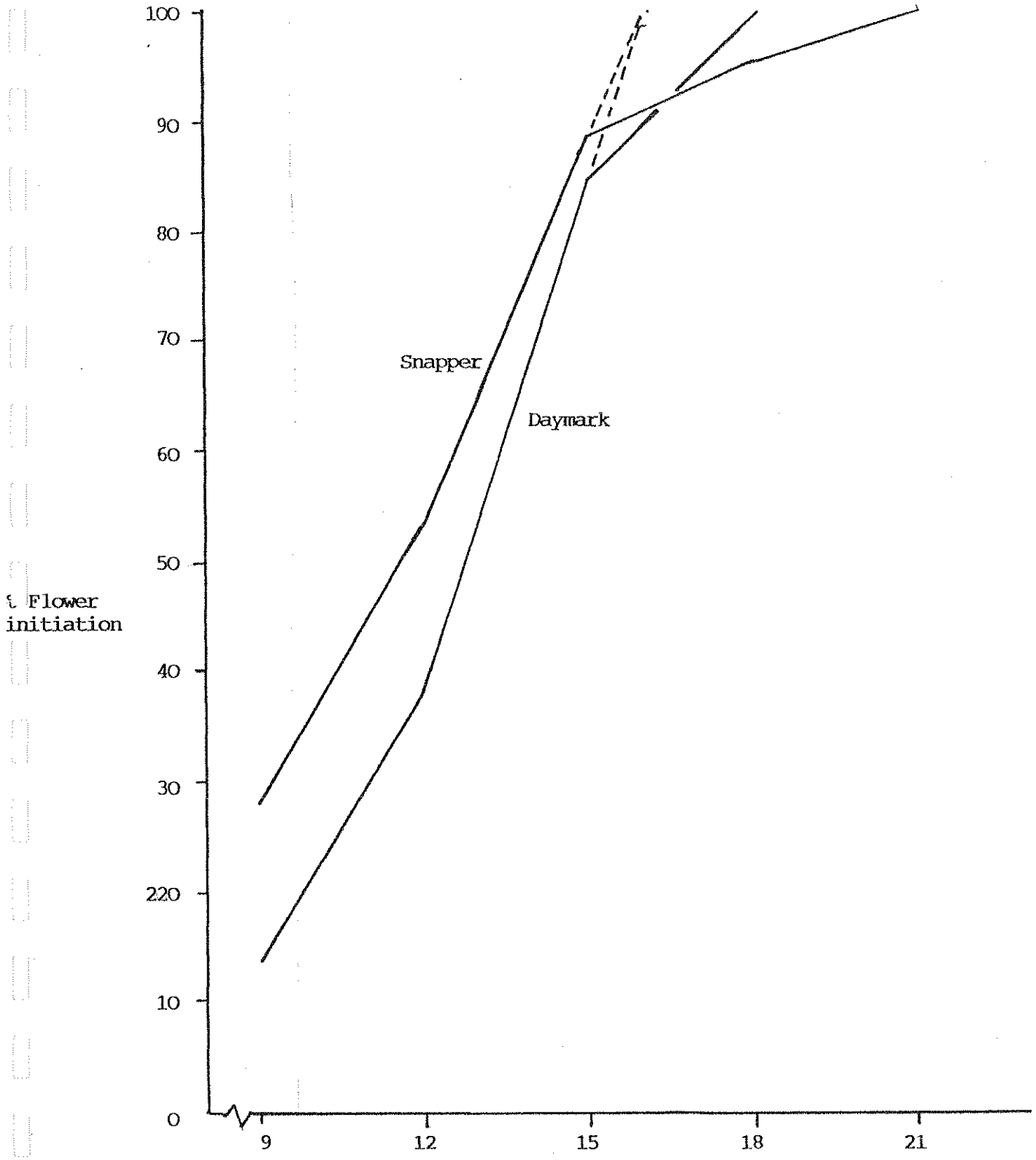
Planting 2. S.D. started 14 Dec 1987

Date	No.Short days	PAR	Running Total	Daily Average
15.12.87	1	0.12	0.12	0.12
16	2	0.23	0.35	0.18
17	3	0.11	0.46	0.15
18	4	0.50	0.96	0.24
19	5	0.49	1.45	0.29
20	6	0.40	1.85	0.31
21	7	0.15	2.0	0.29
22	8	0.87	2.87	0.36
23	9	0.31	3.18	0.35
24	10	0.56	3.74	0.37
25	11	0.95	4.69	0.43
26	12	0.25	4.94	0.41
27	13	0.82	5.76	0.44
28	14	0.41	6.17	0.44
29	15	0.11	6.28	0.42
30	16	0.14	6.42	0.40
31	17	0.77	7.19	0.42
1.1.88	18	0.13	7.32	0.41
2	19	0.64	7.96	0.42
3	20	0.72	8.68	0.43
4	21	0.77	9.45	0.45

Appendix 4. Planting 2. Total number of days from planting to harvest

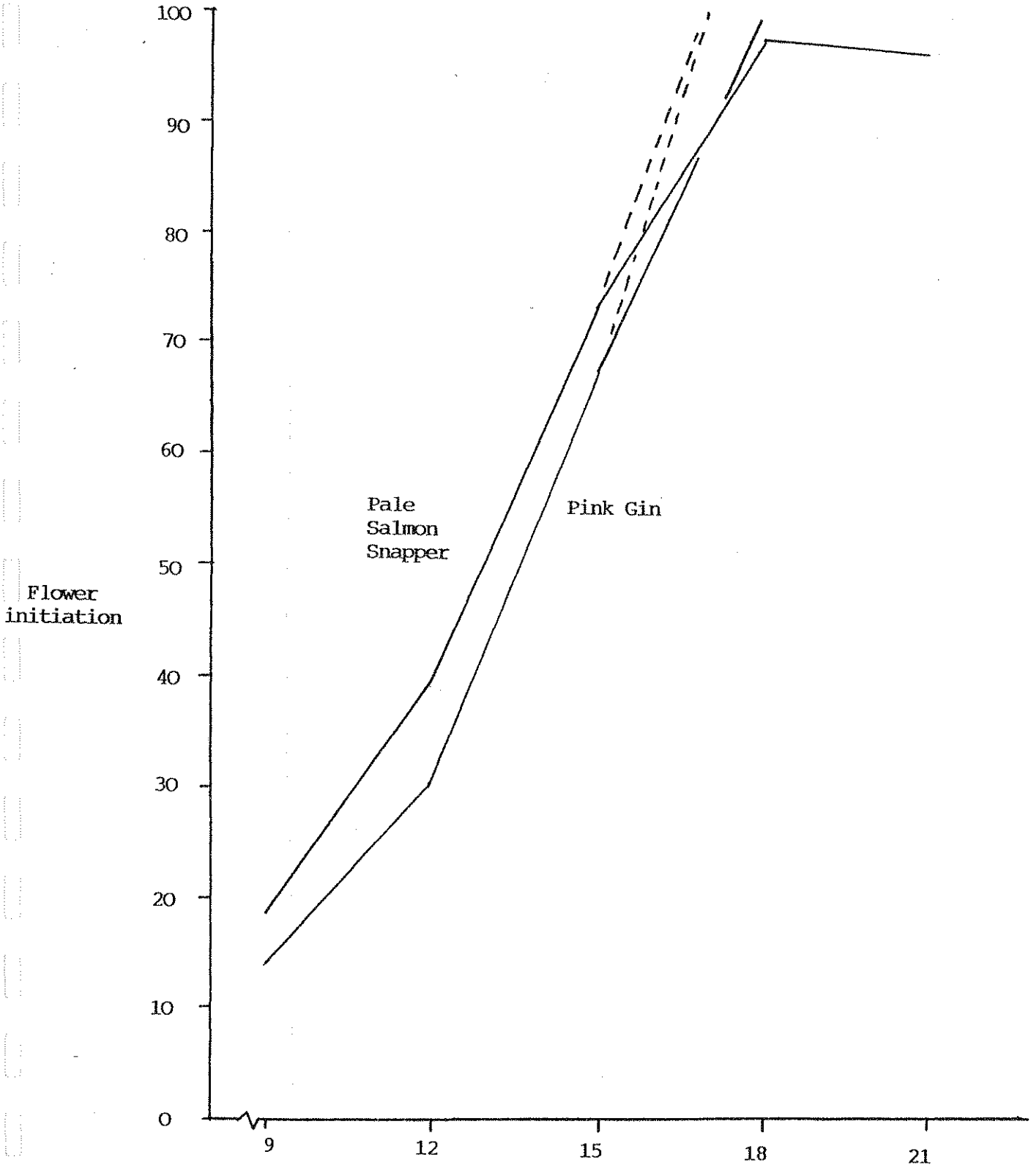
Cultivar	Number of short days before interruption				
	9	12	15	18	21
Delta	106	110	110	112	110
Snowdon	108	108	110	108	109
Snapper (Pink)	98	98	98	99	99
Snapper (Pale Salmon)	103	102	104	103	105
Rosado	102	100	102	102	102
Pink Gin	104	101	102	100	101
Texas	110	107	107	110	110
Robeam	105	106	107	107	107
Daymark	99	99	100	101	100
Cassa	99	99	104	100	100
White Fresco	107	108	111	107	108

Figure 1. Fast group - initiation in 16 days



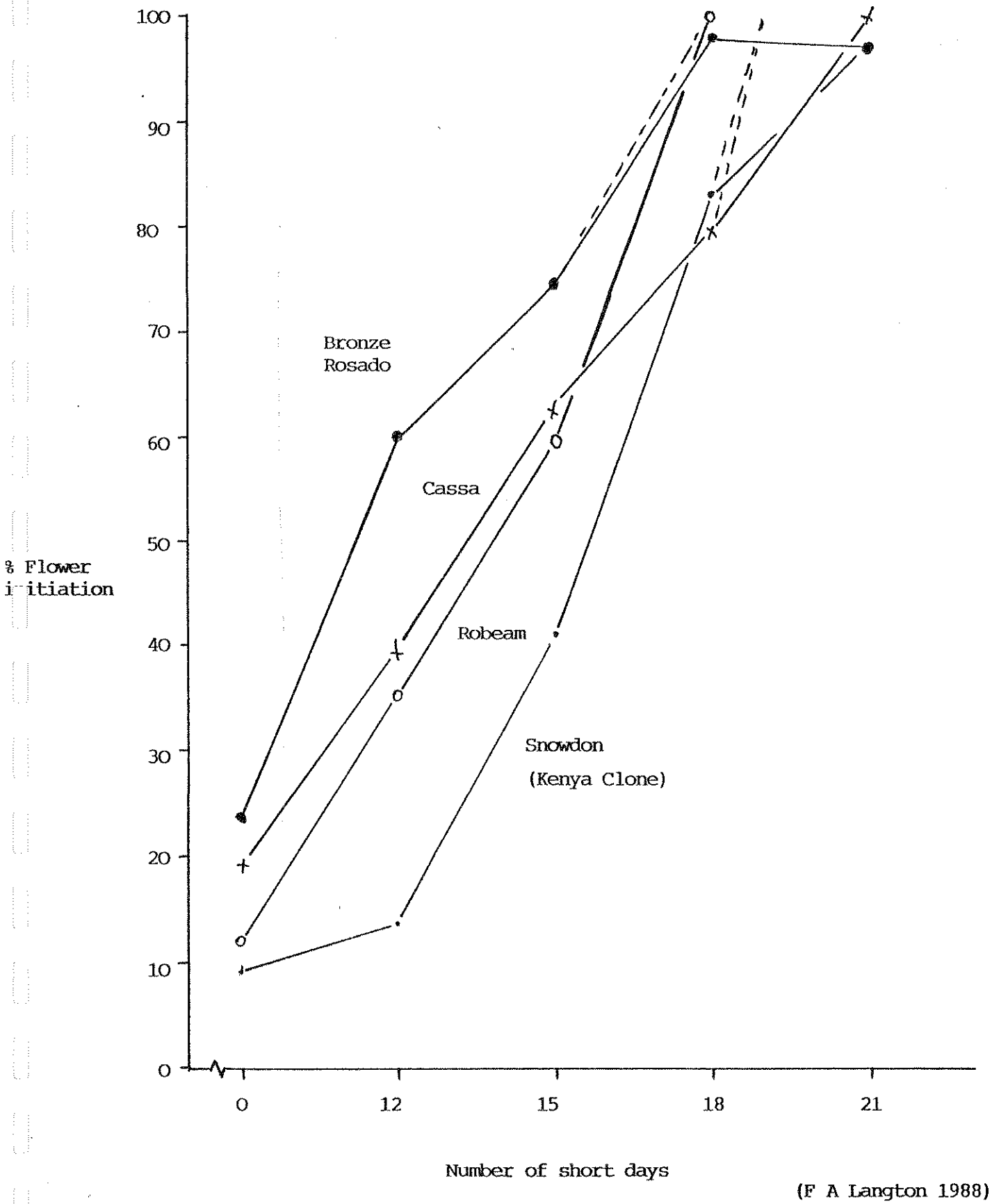
(F A Langton 1988)

Figure 2. Fast/medium group - initiation in 17 days



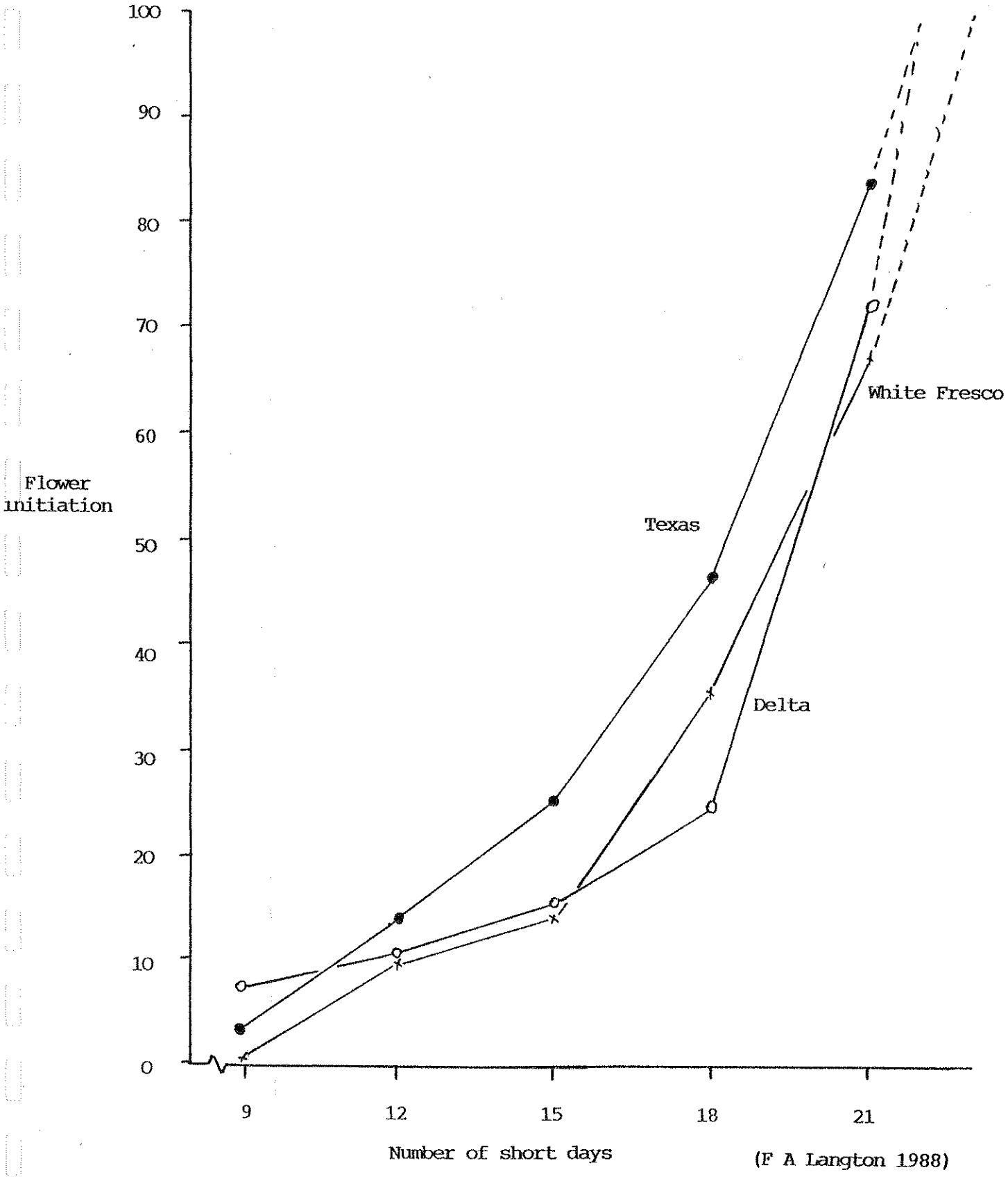
(F A Langton 1988)

Figure 3. Intermediate group - initiation in 18/19 days



(F A Langton 1988)

Figure 4. Slow group initiation in 22/23 days



Appendix 5

Contract between The Glasshouse Crops Research Institute and ADAS (hereinafter called the "Contractors") and the Horticultural Development Council (hereinafter called the "Council") for a research/development project.

PROPOSAL

1. **Title of project** PC/12/87.

Development of interrupted-lighting schedules for a range of AYR spray chrysanthemum cultivars.

2. **Background**

Interrupted lighting which is the intercalation of a period of long days into the short-day phase of spray-chrysanthemum production to improve winter quality is now practiced by many leading growers in the U.K. The timing of the interruptions is critical; if long days are introduced before all lateral shoots are committed to flowering, low grade 'double-decker' sprays result; if introduced much after budding has been completed, there will be little useful effect. Growers currently use a 'calendar' approach where the length of the short-day period before interruption is varied from month to month to reflect 'average' seasonal influence on the speed of flower initiation. The average daily light integral is the major uncontrolled factor determining the speed of flower initiation in short days and, hence, the length of the short-day period which needs to elapse before interruption begins.

3. **Objective of this project**

There are marked differences between cultivars in their flowering responses to light integral. For interrupted lighting to have maximum commercial value, cultivars need to be grouped into types of similar response so that detailed light-integral relationships need only be known for a smaller number of 'key' representatives.

4. Potential benefit to the Industry

The improvement in quality and production has been estimated by a leading grower who uses the technique to be worth £25,000 per hectare per annum when all goes well which, extrapolated to the AYR Industry in total, would be equivalent to an added crop value of £1.4 million. However, the greatest value of the technique is probably to reduce the vulnerability of the U.K. Industry to imports.

5. Closely related work already completed or in progress

The relationship between average daily light integral and the number of short days for flower commitment has been determined for three widely grown cultivars in experiments at Littlehampton. This has led to the concept to 'light-integral monitoring' whereby growers with environmental computers and Kipp solarimeters (or equivalent) or access to relevant light-integral data (supplied by ADAS) may predict, with greater accuracy than hitherto, when interrupted lighting should begin. The testing and further development of this concept began at Efford EHS in 1985/86.

6. Description of the work

A series of experiments over a one-year period is proposed at:

a) IHR - L, to determine relationships between the average daily light integral and the number of short days for commitment to flowering in a further three to five chrysanthemum cultivars. These will comprise the 'key' cultivars. Ten or more trials will be carried out during winter/spring 1987 and autumn/winter/spring 1987/88 with plants being transferred at regular intervals from inductive short days to continuous long days to assess the extent of flower initiation at each transfer date. These findings will be related to the average daily light integral received by the plants to give predictive tables which could be used by growers. (The project will span 18 months, but costs will be based on 12 months work).

b) Efford EHS, to determine similarities in response to short days between nine cultivars to give groupings characterised by the 'key' cultivars. Relationships will be examined in trials starting in January 1987 and again in the autumn of the same year. Speed of flower initiation of each cultivar will be assessed by examination of the spray form ('double-deckering' etc.) of plants having had varying periods of short days prior to interruption. This procedure should also give information on the effects of delaying the start of interruption by several days after all buds are committed to flower.

7. Commencement date and duration

Commencing 1.1.87, duration 18 months.

8. Staff responsibilities

Project leader: Dr F A Langton

At IHR - L; one experimental worker plus supervisory input from F A Langton and nursery, computing and statistical backup.

At Efford EHS; technical inputs from M J Leatherland, an S.O. and an A.SO., plus nursery staff time.

9. Location

At IHR - Littlehampton and Efford EHS.

10. Costs

The following costs have been agreed for the overall project:

At IHR - L £28,000
At Efford EHS £8,000

11. Payment

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

Project year 1 2 3

£36,000

(work extending over 18 months)

Quarter/Year	1987	1988	1989
1		7,000	
2		7,000	
3	2,333	4,667	
4	7,000		

ADAS (Total £8K, of which £1K subject to satisfactory completion, or repetition, of first quarter trial)

Quarter/Year	1987	1988	1989
1	2,000	1,000	
2	1,000		
3	2,000		
4	2,000		

TERMS AND CONDITIONS

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

Signed for the Contractor(s) Signature.....
Position.....
Date.....

Signed for the Contractor(s) Signature.....
Position.....
Date.....

Signed for the Council Signature.....
Position.....
Date.....7.5.87.....

TERMS AND CONDITIONS

The terms and conditions upon which the Ministry of Agriculture, Fisheries and Food (MAFF) is prepared to undertake research and development work for you are as follows. Any variation must be agreed in writing and signed by the officer acting on behalf of MAFF. No conditions appearing on any order form or other document provided by you to MAFF shall be applicable.

1. The work to be done and the dates and amount of payment are set out on the first pages of this form and in the attached schedule.

2. MAFF cannot undertake to provide services of this type for you alone.

3. The customer will be free to publish the results generated by his sponsored treatments together with data from standard treatments without requiring MAFF permission, but any mention by you of MAFF must be approved in advance in its context by MAFF and you will not make any reference to MAFF without obtaining such approval. MAFF will not publish the results of the customer's sponsored treatments without obtaining approval from the customer.

4. All materials and items of equipment which are to be supplied by you for the purposes of the work shall be delivered, assembled, maintained, dismantled and collected at your cost and in accordance with the requirements of the MAFF staff responsible for the work. All equipment and other accessories (except those owned and provided by you) and all materials used shall remain the property of MAFF.

5. MAFF shall not be held responsible for failure or delay in carrying out the work in whole or in part due to any circumstances whatsoever beyond its reasonable control.

6. If any payment is not made on the due date MAFF reserves the right to cease work and if it thinks fit terminate the contract. The customer forfeits all rights to the receipts of the results if payment is not made as agreed.

7. If there is more than one party providing finance for the work, MAFF's agreement to do the work is conditional upon agreement being reached with all parties.

8. Any notices to be issued shall be in writing to the addresses at Section 5 on the front of this form and if sent by prepaid first class post shall be deemed to be served on the second business day after posting.

9. The charges quoted on this form are exclusive of VAT unless specified to the contrary.

10. This contract may be terminated by either party on three months' notice. On such a termination payment will be made in respect of the period up to termination, pro rated on a cost basis or, if necessary, on a time basis.

11. MAFF shall be entitled to the copyright in respect of any working papers and any report(s) produced. You will be entitled to publish the report subject to the provisions of condition 3. If any patentable discovery is made in the course of the work MAFF and the customer shall attempt to negotiate terms for the exploitation of that discovery, sharing the benefit as may be reasonable in the light of their respective contributions to the making of the discovery and the expected expenses of the exploitation. If agreement cannot be reached the terms shall be determined by a barrister agreed by MAFF and the customer or in default of agreement by the President of the Law Society and such barrister shall act as an expert and not as arbitrator.

12. If the work involves your employees attending MAFF premises, you will remain responsible for their salaries and all other associated costs. You will procure that such employees sign the Official Secrets Acts if required by MAFF. You will procure that such employees comply with MAFF security regulations whilst on MAFF premises. You will hold MAFF indemnified against any claim made against it as a result of any tort committed by the employee whilst on MAFF premises. MAFF may at any time at its absolute discretion refuse to accept or continue to accept any particular employee on its premises. MAFF is under no obligation to allow your employees to witness work being done.

13. You will provide accurate information as to the composition of any materials supplied by you, and will give MAFF notice of any hazards in their use known or suspected by you.

14. Our agreement will be subject to English law and we both hereby submit to the jurisdiction of the English courts.

Signed by
on behalf of MAFF date .....

R F Clements, Contract Manager

Agreed by
on behalf of
customer date .....