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CONTRACT REPORT

No. C88/0540
Temperature regimes for
long season tomatoes
final report to H.D.C.

Pc 2

ADAS

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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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Director Efford EHS
October 1988

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ADAS

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Summary

During 1987 and 1988 trials were conducted on long season tomato crops to study different temperature regimes. Interest in regimes used in Holland encouraged growers to use higher night temperatures and increased ventilation but in both years this 'Dutch' regime caused reductions in yield to the end of May due to poor set and lower CO_2 levels. In 1988 four regimes were examined giving either Blueprint or Dutch regimes continuously through the season or changing from one to the other in April. Although the blueprint regime followed by Dutch regime gave the highest end of season yield, differences were not statistically significant. There was however some evidence of increased returns from the Dutch regime used from mid summer onwards although when balanced against the extra fuel use it is unlikely that this treatment would do more than break even.

Differences between the performance of the Dutch regime in the two seasons of this trial were discussed and were probably due mainly to changes made in the setpoints and the accuracy of the control achieved.

Although there is some scope for manipulation of the Blueprint regime particularly with varieties such as Counter, it generally provides a reliable growing environment giving good yield and quality throughout the season.

Introduction

Following interest in new temperature regimes being used for tomato crops in Holland the Horticultural Development Council (H.D.C.) provided funding for two years of trials at Efford EHS to examine various temperature strategies.

In the first year the traditional British 'ADAS Blueprint' regime was compared with a standard Dutch regime in use at the time and two intermediate regimes. The results of this work were fully written up as contract report PC2/87 available from the H.D.C. at Petersfield.

A number of points arose from the 1987 work. The Blueprint regime gave higher yields than the Dutch regime to the end of May. This was due in part to poor fruit set from the Dutch regime on the early trusses and in part to reduced fruit size as a result of lower CO_2 levels. There was however a compensating yield increase in the summer from the Dutch regime such that both treatments yielded equally to the end of September. There was also a loss of early quality from the Dutch regime due largely to poor fruit shape but summer quality was worse from the Blueprint regime.

It was therefore concluded that both regimes had their advantages and disadvantages and that the most promising compromise might be to consider a combination beginning with the Blueprint regime for the spring and changing to the Dutch regime for the summer. Therefore in 1988 this combination regime and the reverse combination beginning with the Dutch regime were compared with the two continuous regimes.

MATERIALS AND METHODS

Site

The trial was carried out at Efford EHS, Lymington, Hampshire, in a multi-compartment unit comprising two separate blocks of six compartments each of 81 m^2. The centre four compartments of each block were used, making eight in total. Each compartment was equipped with independent control of the environment linked to a Priva Computer. The heating was by two hot water pipes per double row. The level of control was such that temperatures at night could normally be controlled to within 0.1^{0}C of the setpoint.

Treatments

Temperature Treatments

From standing out (9 December)	From 18 April
Blueprint	Blueprint
Blueprint	Dutch
Dutch	Blueprint
Dutch	Dutch

Blueprint	Night ^{0}C	Day ^{0}C	NightVent ^{0}C	Day Vent ^{0}C
Standing out (9 Dec)				
to first anthesis (Stage 2)	16	18	25	24
1st Anthesis (4 Jan)				
to start of pick (Stage 3)	16	20	25	24 + 2 *
Weekly reduction				
from start of pick (25 Feb)	16	19.5	25	25
	16	19.0	25	24
	16	18.5	25	23
	16	18.0	25	22
25 March to end of crop	16	18	25 **	21

Notes

* Additional two degrees dependent on light level e.g. $24^{0}C$ at 0 mW cm^{-2}
$26^{0}C$ at 20 mW cm^{-2}

until 19 Jan then straight $26^{0}C$

** From August a minimum night ventilation setting of 3% was given.

No minimum pipe temperatures were used.

Dutch

	Night ^{0}C	Day ^{0}C	Night Vent	Day Vent
Standing out (9 Dec)	18	18	20	19
16 Dec to 4/5 truss in flower	17.5	18	20	19
4/5 truss in flower (12 Feb) to end of crop	17	17.5	20	18

Notes:

1. Minimum pipe temperature 40^{0}C night
   50 to 40^{0}C day (50 at 0 mW cm^{-2}
   40 at 20 mW cm^{-2}
   until 2 June then range reduced to 40-35^{0}C

2. Minimum night ventilation of 3% from August

In both temperature regimes no pipe heat was available during week 25 while boilers were maintained.

The time at which temperature regimes were changed was based on the 1987 results which suggested that the yield patterns of the two regimes began changing in June and that the fruit harvested then would have been affected by conditions from the end of April onwards. It was originally decided that the change should be made on 30 April but as the plants began to lose vigour earlier than expected and the Dutch regime was reported to improve summer vigour, this was brought forward to 18 April.

Varieties

Three varieties were used within each temperature regime.
Calypso, Counter, Criterium

Design

The four temperature regimes were arranged as factorial combinations of two factor levels, e.g. early and late temperatures. This increased the replication available to early season temperature treatments. The relationship between temperatures regimes and varieties was in the form of a split plot design with each variety appearing in each replicate of each temperature treatment. Each temperature regime appeared an equal number of times in each of the two blocks of four compartments. Each plot contained 20 recorded plants and was guarded at the ends of the rows. Each compartment had a single guard row at each side.

Culture

Propagation

Seed was sown into 38mm rockwool multiblocks on 2 November 1987. These blocks were pre-soaked with nutrient feed to a pH of 6.0 and a conductivity of 1.5 mS. Trays were covered and kept on a heated bench until germination. Block temperature was maintained at 24^{0}C until germination. After seedling emergence block temperatures were lowered to 21^{0}C and the trays were uncovered. Conductivity was raised to 2.5 mS. Air temperature was maintained at 24^{0}C day and night for four days then 20^{0}C day and night until blocking on.

Blocking on

Propagation cubes were blocked on into 0.65 l rockwool blocks or 11 November. Conductivity was maintained at 2.5 mS in the rockwool until third true leaf stage then raised gradually over 10 days to give a slab conductivity of 6.0 mS by feeding at 5.0 mS. Subsequent irrigation was given if pH exceeded 6.5 or if conductivity exceeded 6.5 mS. Plants were spaced as necessary. Temperatures were 16^{0}C night and 21^{0}C day until 20 November when they were raised still further to 18^{0}C day and night to prevent excessive cooling of the propagation blocks. On the 25 November the propagation area was lined with polythene to alleviate the problem. It is thought that this high night temperature may have been responsible for some of the abortion of the first truss.

Growing house

Training: Standard layering from 2.4m wires

Density: 2.61 plants/m^2

Row spacing: 4.76 mm

Irrigation

Feed was given on a time clock basis until mid-February. From then on a light dependent control system on the Priva Computer was used. From standing out to start of pick, slab conductivity fluctuated between 4.5 and 7.0 mS. This was partly by design depending on the condition of plants and partly due to the inflexibility of the time clock watering system. From start of picking on 24 February slab conductivity was held consistently at around 4.0 mS until mid April and then at 3.0 mS until the end of May. From June, a slab conductivity of 2.5 mS was maintained rising to 3.0 - 3.5 mS from early August. ADAS recommendations for feeds were followed as far as possible with adjustments as necessary through the season.

Pest and Disease Control

Whitefly was successfully controlled using weekly introductions of Encarsia formosa, no chemicals were used. Botrytis was controlled using a propylactic programme of Sprays including Elvaron (dichlofluanid), Rovral (iprodione), Bombardier (chlorothalonil).

Pollination

Flowers were pollinated 3-4 times a week by electric bee until mid February. From then until the end of April plants were truncheoned three times weekly and then water jetting was used until the end of the season except on dull humid days.

Temperature

Experimental treatments were given from final spacing in the growing house on the 9 December.

CO_2 Enrichment

The setpoints were as follows:

Propagation - January	1000 v.p.m./500 v.p.m (500 if vents more than 5% open)
February - July	1000 v.p.m./350 v.p.m
August	500 v.p.m./500 v.p.m

This was the same for all compartments.

In December and January during stages 2 and 3, CO_2 levels were maintained between 900 and 1000 v.p.m regardless of temperature except on very bright days when the Dutch regime vented earlier. Under these circumstances the Blueprint regime ran slightly lower, with the Dutch regime running between 600 and 800 depending on the degree of ventilation.

From February the degree of ventilation allowed was increased and the second level of CO_2 enrichment (vents above 5%) reduced to 350 v.p.m. From then on average daily levels were generally lower from all treatments with the Blueprint regime ranging from 350 on bright days to 700 on dull days. The Dutch regime also maintained 350 v.p.m. on bright days and on dull days in early spring still managed to get up to 600 or 700 v.p.m. However, more often and certainly during the later part of the season the Dutch regime rarely exceeded 400 v.p.m.

In general terms therefore lower CO_2 levels were maintained in the Dutch regime at most times during the life of the crop but the differential depended on weather conditions and the differences in ventilation settings through the life of the crop. In hindsight, a lower, fixed CO_2 regime independent of the degree of ventilator opening would have enabled more similar CO_2 levels to be maintained in all compartments. This however would not have given the maximum potential to the Blueprint regime and would not necessarily have reflected commercial practice.

Other dates:

Date of first pick: 24 February

Stopping date: 16 August

Final harvest: 30 September

Assessments

Plots were harvested three times a week on Mondays, Wednesdays and Fridays. Both replicates were fully graded until 8 April. From 11 April, replicates were graded alternately. When harvests were not graded the bulk weights were apportioned to grades according to the gradeout of the previous graded harvest. Weight and gradeout data were collected in the packing shed on a portable Epson computer. These were then transferred to discs using the Station's Comart Computer which provided regular summaries of the results. Discs were sent to Rodney Edmondson at the statistics section of the Institute of Horticultural Research at Littlehampton for analysis.

Other records taken during the trial.

1) Daily monitoring of slab pH and conductivity
2) Routine samples of solution for chemical analysis
3) Date of 1st anthesis trusses 1-10 (8 plants/plot)
4) Number of fruit set and number marketable trusses 1-10, 14, 18 and 22 (8 plants/plot)
5) Assessments of level of truss/flower abortion of first truss
6) Assessment of kinked trusses - trusses 3-6
7) Records of plant height at intervals up to the wire
9) Height at end of season
10) Number of trusses at end of season

Statistical analysis:

The varieties analysed were:

1. total yield in kg m^{-2}
2. percentage class I of total
3. percentage yields of C,D,E and F fruit of class I
4. monetary value in pounds sterling m^{-2}

The experiment was analysed as a split plot design with degrees of freedom partitioned into three levels; replicates, temperature regimes and varieties. The analysis was performed on monthly cumulation periods but up to the end of April only one temperature factor (early temperature) was included in the analysis. From May onwards all combinations of early and late temperature were analysed together. Percentage data was analysed with and without the angular transformation but as few significant differences occurred in either only the untransformed data have been presented.

Results

The environment:

Weekly averages of temperature, humidity and fuel use are presented graphically as appendices. Gaps have been left on the graphs indicating that the changeover of the regimes. where appropriate, took place in week 16 (18 April). It should also be noted that the boilers were turned off for maintenance in week 25.

Temperature

Figures 1 to 3 show the 24 hour, day and night temperatures plotted on a weekly basis. Appendix 1 tabulates these figures and in addition provides monthly averages. For the first two months after standing out the mean 24 hour temperature was higher in the Dutch regime. From February through until May the mean 24 hour temperatures were very similar for both treatments. From June to the end of the season the average temperature from the Blueprint was slightly higher. These changes in balance between the two regimes from May onwards appear to be related to changes in daylength rather than any other factor.

As might be predicted from the set values the night temperature in the Dutch regime was consistently higher than the Blueprint although from week 18 onwards the difference was smaller than in 1987. This was due to the provision of greater capacity for night ventilation allowed in 1988.

Conversely the day temperatures were higher in the Blueprint regime for most of the season. The difference from May onwards was also smaller than in 1987. This was due to the lower minimum pipe settings used in 1988.

Humidity

The night humidity patterns were very similar to those observed in 1987, with the Dutch regime consistently lower than the Blueprint. Although the day humidity was lower in the Dutch regime, the difference was not as great in the summer as it had been in 1987. This was due to the reduction in the minimum pipe temperature setting. It is interesting to note the increase in night humidity in both regimes from around the mid-March period. This happened both in 1987 and 1988.

Fuel use (Figure 6)

Fuel use was calculated from the flow and return temperatures and the flow rate of water through each compartment. The calculation applied was:

$$\frac{(\text{Flow } ^{0}\text{C return } ^{0}\text{C}) \times 1s^{-1} \times 3600 \times 24 \times 7 \times 4200}{81 \times 1000000} = \text{MJ m}^{-2}\text{ Week}^{-1}$$

Where:

$1s^{-1}$	=	flow rate
3600	=	seconds/hour
24	=	hours/day
7	=	days/week
81	=	compartment area
4200	=	Joules/^{0}C/litre water
1000000	=	Joules/MJ

Fuel use until the end of March was similar from the two regimes with the Dutch regime using slightly more fuel. This might be expected on the basis of the high night temperature settings. In February however, the position was reversed due to slightly cooler ambient conditions and a reduction in the temperature settings in the Dutch regime from 12 February. The same general comment can be made as for 1987 that the fuel use in the early season on average is similar for both regimes. The additional fuel use comes mainly from April onwards with the use of minimum pipe temperature settings. Although the fuel use for small compartments does not reflect that from larger areas the figures recorded at Efford can be used as a guide. The total fuel use for the season was therefore:-

Blueprint	1516 MJ m^{-2}
Dutch	2121 MJ m^{-2}

This represents an increase of 40% if the Dutch regime is used. This conclusion agrees well with that from 1987.

Plant Growth

At the beginning of the season, a sample of eight plants were chosen at random from each plot and marked. All subsequent records were taken from these eight plants.

Date of first anthesis

There were a number of plants which aborted their first trusses. It is thought that this was caused by a combination of poor light and high propagation temperatures but highlights interesting treatment differences.

Table 1. Number of plants with aborted first truss (sample of 8)

	Variety			
Treatment	Calypso	Counter	Criterium	Mean
Blueprint	0.5	3.3	4.3	2.7
Dutch	2.8	6.3	5.5	4.9
Mean	1.7	4.8	4.9	-

The Dutch regime showed increased truss abortion. In 1987 there was no flower abortion but it was shown that the Dutch regime reduced the amount of seed set in the fruit.

Table 2. Date of first anthesis trusses 1-4

	Variety											
Treatment	Calypso				Counter				Criterium			
	1	2	3	4	1	2	3	4	1	2	3	4
Blueprint	4/1	18/1	27/1	5/2	2/1	13/1	22/1	30/1	5/1	15/1	25/1	1/2
Dutch	2/1	15/1	24/1	2/2	31/12	17/1	21/1	28/1	1/1	18/1	23/1	31/1

The dates of first anthesis for trusses 5-10 can be found in appendix 4. From the dates of those first trusses which did not abort it can be seen that Counter was on average setting two or three days earlier than Calypso. This greater rate of development was enhanced in the Dutch regime by higher mean temperatures resulting in truss abortion particularly in the Dutch regime. The slower development rate of the Calypso reduced the degree of truss abortion. Criterium is known to be a more sensitive variety and is not particularly well suited to poor light conditions so despite a development rate similar to Calypso it behaved more like Counter.

From Appendix 4, it can be seen that by February the anthesis dates from both regimes became similar for all varieties. This was assisted by good light conditions during February. During the latter part of February, 24 hour temperatures were higher in the Blueprint regime due to higher ventilation set points in the bright conditions. This advanced the setting of trusses 9 and 10 by approximately 3 days for Criterium and Calypso although did not affect Counter presumably due to its naturally free setting characteristics.

The number of fruit set and marketable on trusses 1-10, 14-18, and 22 can be found in appendix 5. An extract is given in table 3.

Table 3. Number of marketable fruit trusses 1-10 (Sample of 8

	Truss number									
	1	2	3	4	5	6	7	8	9	10
Blueprint										
Calypso	3.7	8.8	9.4	9.7	9.3	9.9	9.7	9.8	9.3	9.1
Counter	1.9	7.7	8.8	9.0	8.5	8.5	9.4	9.0	9.6	9.0
Criterium	1.3	7.9	9.2	9.4	8.4	9.2	9.3	9.1	9.4	9.4
Dutch										
Calypso	1.1	8.0	9.4	9.9	9.6	9.5	9.3	9.4	9.5	9.2
Counter	0.5	5.4	9.0	9.5	9.0	9.2	9.3	9.1	9.4	9.3
Criterium	0.5	5.9	9.4	10.0	9.1	9.5	9.2	9.0	9.6	8.8

It is interesting that in the Blueprint regime all three varieties performed acceptably on the second truss but in the Dutch regime, Counter and Criterium were still suffering from flower abortion. The result for truss 22 (see appendix 5) would seem to indicate that those treatments where the Dutch regime was given from the middle of April set slightly more fruit on the truss than those given in the Blueprint regime. This helps explain the summer yield advantage from the Dutch regime seen in 1987 when it was suggested that in the absence of other causes an increase in the number of fruit set was the only possible explanation.

Plant Height

Table 4. Plant height at intervals - cm

Treatment	Date 5/1	3/2	17/2	3/3	15/3	29/3
Blueprint						
Calpso	72	150	193	249	287	323
Counter	69	152	195	250	294	330
Criterium	68	158	205	267	309	346
Mean	70	153	198	255	297	333
Dutch						
Calypso	76	152	190	235	266	350
Counter	71	150	185	231	264	296
Criterium	72	155	192	243	280	318
Mean	73	152	189	236	270	321

Until the end of January the heights from both temperature treatments were similar. A difference in height of approximately 10% had developed by the middle of March but this difference was reduced by the end of March. By the end of the season the Dutch regime plants were on average 56 cm shorter than those from the Blueprint regime (Tables).

There is a smaller difference than the 96 cm found in 1987. Intermediate treatments gave intermediate stem lengths. The number of trusses produced did not vary significantly between any of the treatments (Table 5).

Table 5. Stem length and truss number at end of season

Treatment	Stem length cm	Truss number	Mean intertruss distance cm
Blueprint/Blueprint			
Calypso	695	28.5	24.4
Counter	634	28.9	21.9
Criterium	676	28.3	23.9
Mean	668	28.6	23.4
Blueprint/Dutch			
Calypso	661	27.1	24.4
Counter	641	29.3	21.9
Criterium	660	29.1	22.7
Mean	654	28.5	23.0
Dutch/Blueprint			
Calypso	658	27.4	24.0
Counter	626	28.9	21.7
Criterium	650	28.6	22.7
Mean	645	28.3	22.8
Dutch/Dutch			
Calypso	614	27.8	22.1
Counter	624	28.7	21.7
Criterium	598	27.4	21.8
Mean	612	28.0	21.9

Truss kinking

An assessment was made of trusses 3-6 prior to the start of picking of those trusses. The results are shown in table 6 and show no difference between the regimes.

Table 6. Assessment of truss kinking

Treatment	No. of kinked trusses/plot (sample of 8)				
	Truss number				
Treatment	3	4	5	6	Mean
Blueprint					
Calypso	6.3	7.3	7.3	6.8	6.9
Counter	4.5	6.8	7.0	6.5	6.2
Criterium	4.3	4.5	7.0	6.0	5.5
Mean	5.0	6.2	7.1	6.4	6.2
Dutch					
Calypso	6.8	7.3	7.3	6.0	6.9
Counter	4.3	5.3	6.8	7.3	5.9
Criterium	4.0	5.3	7.0	5.5	5.5
Mean	5.0	6.0	7.0	6.3	6.1

Yield

Because of the factorial nature of this experiment the analysis has been split into two parts. The effect of early treatments have been analysed throughout the season but an analysis for the late temperture treatments is provided only from May onwards.

Table 7 shows the effect of early temperature on monthly yields. In February and March there was a significant reduction in yield from the Dutch regime (P = 5%). This was probably a result of the flower abortion on the first truss confirmed by the significant interaction between temperature and varieties also found in this period. It will be remembered the fruit set records for trusses 1 and 2 indicated that Calypso behaved differently to Counter and Criterium in response to the two temperature regimes.

The yield for April also showed a significant reduction from the Dutch regime. Reference to table 9 shows that there was an increase in the % fruit greater than 57 mm (grade C). This is consistent with higher CO_2 levels achieved in the Blueprint regime as the degree of ventilation in the Dutch regime increased and is also consistent with the results of 1987.

The cumulative yield to the end of May showed a significant difference (P = 7%) between the two regimes. The difference of 2 kg m^{-2} (8 tons/acre) was almost identical to the difference found at the same time in 1987. There were no significant affects of the early temperature treatments after May.

Table 8 shows the affect of the temperature treatments given from 18 April onwards. Only the results for June were statistically significant (P = 0.1% S.E.D. 0.077) suggesting that maintaining a Dutch regime in June reduced the yield. The Dutch regime gave the smallest overall yield to the end of the season and was still 2 kg m^{-1} behind the continuous Blueprint by September whereas in 1987, it made up this difference during the summer. This may have been due to the higher mean 24 hour temperatures given for the Dutch regime in 1987 than were maintained in 1988. The yield pattern was very similar to 1987 with the Dutch regime reducing yield until June and thereafter tending to increase yield slightly. There were also significant varietal differences in June, July and September but these were not associated with consistent significant interactions with temperature regime and have not been included.

Fruit Size

Tables 9 and 10 show the distribution of Class I fruit into grades C (above 57 mm) and D (47-57 mm). The fruit size affects on yield in the period up to April have already been discussed. The early temperature treatments gave a significantly higher percentage of size C fruit from the Blueprint regime (P = 5% S.E.D. = 1.48 for March and 3.30 for April at 5 d.f.). There was some evidence that the Dutch regime gave more C grade fruit in August and September but this did not reach a formal level of significance.

The percentage of fruit in size D was not significantly affected by the treatments given either in the early season or the main season.

Fruit Quality

A more detailed assessment of individual aspects of fruit quality will be made available in the 1988 fruit quality report for the H.D.C. The quality as expressed by % class I gradeout in the packing shed is given in table 11. There were no statistically significant differences in quality up to June. From July there was a trend for the late Blueprint regime to give poorer quality. This difference was significant in August and September (P = 5%). There was some evidence of differences between varieties but these did not reach formal significance and there was no evidence of any interaction beteen varieties and temperature regimes.

In 1987 there were differences in early quality between Dutch and Blueprint regimes. This was due to poor seed set and consequent poor shape of fruit on the first two trusses. In 1988 the poor set took the form of complete truss abortion and there was no reduction in quality of the remaining fruit. Differences in quality between Dutch and Blueprint regimes in the summer were small in 1987 apart from September. Quality differences in the summer of 1988 between treatments were of similar magnitude to those in 1987.

A number of quality attributes were examined at intervals throughout the season as part of the H.D.C. fruit quality project. There was an interesting change in the degree of both radial cracking and fine net cracking following the change over to the summer treatments on 18 April. A sample taken in week 15 showed very low levels of these two disorders whereas in a sample taken 5 weeks later the level of both types of cracking had increased. In the Dutch/Dutch regime there was a moderate level of cracking but much more in the Dutch/Blueprint regime whereas in the other two regimes the increase was much less noticeable. Reference to figure 3 shows the considerable reduction in night temperature which occurred at this time and it seems likely that this might be to blame. The same change in temperature but increasing from Blueprint to Dutch was not detrimental. The level of fine net cracking would not have been detected in the Class I gradeout figures.

Fruit shape was largely unaffected by treatment but blotchy ripening (fruit with advanced ripening of the flower end) showed some differences. The level was generally low until the sample taken in week 25. Counter gave the highest levels particularly in the Blueprint regimes. Excluding Counter the best regimes were either the continuous Dutch or Blueprint regimes indicating that a change in regime in either direction affected blotchy ripening.

Assessments of product life were carried out three times during the season. Blueprint temperatures generally gave firmer fruit but this only reached formal significance in the week 13 sample. From the week 27 sample fruit from the Dutch regime lost more weight during shelf life but differences between temperature regimes were smaller than varietal differences.

The Dutch regime gave the highest dry matter and sugar content. Acidity levels were not affected by temperature. In general therefore, the Blueprint regime produced the best fruits for storage but the Dutch regime gave slightly better internal composition.

Table 7. Effect of early temperature treatment on monthly yield

Treatment	Yield kg m^{-2} Feb+Mar	Apr	May	Total to May	June	July	Aug	Sept	Total to Sept
	**								
Blueprint									
Calypso	1.94	6.22	7.37	15.52	7.71	8.24	6.95	5.77	44.19
Counter	2.49	6.37	7.55	16.39	7.87	7.32	6.72	5.24	43.54
Criterium	2.20	6.21	7.29	15.70	8.32	8.21	7.43	5.73	43.39
Mean	2.21	6.27	7.40	15.87	7.96	7.92	7.03	5.58	44.38
Dutch									
Calypso	2.00	5.00	6.88	13.87	7.56	8.22	6.98	5.72	42.35
Counter	1.67	4.96	7.39	14.01	7.94	7.37	6.69	5.31	41.32
Criterium	1.75	5.20	6.70	13.65	8.42	8.01	7.03	5.44	42.55
Mean	* 1.80	* 5.06	6.99	+13.85	7.97	7.87	6.90	5.49	42.07
S.E.D. two temperature (means) (5 d.f.)	0.158	0.375	0.315	0.713	0.077	0.242	0.180	0.264	1.263
S.E.D. any two variety means within a temperature (12 d.f)	0.137	0.193	0.146	0.365	0.229	0.141	0.327	0.151	0.821

Temperature means significantly different at + = 7%

* = 5%

* * Significant interaction at 1% between varieties and temperatures in Feb/March.

Table 8. Effect of late temperature treatment on monthly yield

Treatment	Yield kg m^{-2} May	June	July	Aug	Sept	Total to Sept
Blueprint/Blueprint						
Calypso	7.35	8.05	8.13	7.65	5.24	43.48
Counter	7.78	8.42	7.08	6.22	4.89	42.93
Criterium	7.01	8.73	7.46	7.36	5.63	44.47
Mean	7.38	8.40	7.55	6.75	5.26	43.63
Blueprint/Dutch						
Calypso	7.39	7.37	8.36	7.24	6.30	44.91
Counter	7.31	7.32	7.57	7.22	5.59	44.15
Criterium	7.58	7.90	8.95	7.50	5.82	46.31
Mean	7.43	7.53	8.29	7.32	5.90	45.12
Dutch/Blueprint						
Calypso	6.94	8.04	8.05	7.10	5.54	42.40
Counter	7.77	8.66	7.41	6.66	5.06	42.07
Criterium	6.79	9.02	7.85	6.96	5.35	42.32
Mean	7.17	8.57	7.77	6.91	5.31	42.26
Dutch/Dutch						
Calypso	6.81	7.09	8.38	6.85	5.91	42.30
Counter	7.00	7.21	7.33	6.72	5.55	40.56
Criterium	6.60	7.81	8.17	7.11	5.54	42.79
Mean	6.81	7.37	7.96	6.89	5.67	41.88

Continued ..

Table 8 - continued

Mean late Blueprint	7.27	8.49	7.66	6.83	5.29	42.94
Mean late Dutch	7.12	7.45	8.13	7.11	5.49	43.50
		***				
S.E.D. late temperature means	0.315	0.077	0.242	0.180	0.264	1.263

*** Statistically significant difference at P = 0.1%

Table 9. Analysis of % Class I fruit > 57 mm diameter (C)

The effect of early and main temperature treatments on % fruit > 57 mm

	% Class I > 57 mm								
Treatment	Feb/Mar	Apr	May	Total to May	Jun	Jul	Aug	Sept	Total to Sept
Blueprint/Blueprint	-	-	12.6	12.9	25.8	15.5	8.0	9.5	14.5
Blueprint/Dutch	-	-	10.1	10.4	25.7	22.4	21.8	16.0	17.4
Dutch/Blueprint	-	-	6.1	3.7	30.0	21.2	9.1	8.8	13.4
Dutch/Dutch	-	-	8.5	6.5	17.8	23.6	15.5	15.6	14.1
Mean early Blueprint	6.0	15.2	11.3	11.7	25.8	19.0	14.9	13.4	15.9
Mean early Dutch	2.1	4.3	7.3	5.1	23.9	22.4	12.3	12.2	13.7
	*	*							
Mean late Blueprint	-	-	9.3	8.3	27.9	18.4	8.5	9.1	14.0
Mean late Dutch	-	-	9.3	8.5	21.7	23.0	18.7	16.1	15.7
							+	+	

+ main temperature means statistically significant at P = 7%

* " " " " " " P = 5%

Table 10. Analysis of % Class I fruit 47-57 mm diameter (D)

The effect of early and main temperature treatments on % fruit 47-57 mm

% Class I 47-57 mm

Treatment	Feb/Mar	Apr	May	Total to May	Jun	Jul	Aug	Sept	Total to Sept
Blueprint/Blueprint	-	-	72.2	58.2	62.2	66.8	72.5	65.9	54.5
Blueprint/Dutch	-	-	74.4	59.6	62.8	65.9	67.8	68.9	56.2
Dutch/Blueprint	-	-	69.8	56.7	59.2	62.7	71.2	63.6	53.2
Dutch/Dutch	-	-	68.6	56.0	68.0	64.5	71.8	67.1	55.2
Dutch/Dutch	79.3	66.7	73.3	58.9	62.5	66.3	70.2	67.4	55.4
Mean early Dutch	78.2	72.7	69.2	56.4	63.6	63.6	72.0	65.3	54.2
Mean late Blueprint	-	-	71.0	57.5	60.7	64.7	71.9	6.50	53.9
Mean late Dutch	-	-	71.5	57.8	65.4	65.2	69.8	68.0	55.7

Table 11. Analysis of % class 1 yield

The effect of early and main temperature treatments on % Class I yields

Treatment	% Class I Feb/Mar	Apr	May	Total to May	Jun	July	Aug	Sept	Total to Sept
Blueprint/Blueprint	-	-	93.7	91.9	92.4	84.8	86.4	79.4	88.8
Blueprint/Dutch	-	-	93.6	92.0	93.8	90.9	93.5	89.1	92.0
Dutch/Blueprint	-	-	88.1	89.7	93.2	85.7	85.2	76.5	87.8
Dutch/Dutch	-	-	91.7	92.2	91.9	90.5	92.3	86.0	91.3
Mean early Blueprint	91.1	90.7	93.6	92.0	93.1	87.9	90.0	84.3	90.4
Mean early Dutch	92.0	91.6	89.9	91.0	92.6	88.1	88.8	81.2	89.5
Mean late Blueprint	-	-	90.9	91.0	92.8	85.3	85.8	77.9	88.3
Mean late Dutch	-	-	92.6	92.0	92.9	90.7	92.9	87.6	91.7
							*	*	**

** late temperature means statistically significant at P = 1%

* " " " " " " P = 5%

Table 12. Effect of early temperature on monthly returns

£ m^{-2}

Treatment	Feb + Mar	Apr	May	Total to May	Jun	Jul	Aug	Sep	Total to Sep
	**								
Blueprint									
Calypso	2.92	8.32	6.74	17.99	5.34	4.25	2.78	2.75	33.11
Counter	3.81	8.50	6.75	19.06	5.49	3.66	2.62	2.38	33.22
Criterium	3.45	8.36	6.43	18.14	5.76	4.14	2.91	2.59	33.54
Mean	* 3.36	* 8.39	6.64	18.40	5.53	4.02	2.77	2.57	33.29
Dutch									
Calypso	3.09	6.72	6.43	16.23	5.30	4.19	2.79	2.70	31.22
Counter	2.57	6.76	6.65	15.97	5.56	3.68	2.59	2.36	30.17
Criterium	2.72	7.10	6.04	15.86	5.86	4.06	2.72	2.38	30.87
Mean	2.79	6.86	6.37		5.57	3.98	2.70	2.48	30.25
S.E.D. two temperature means (5 df)	0.232	0.538	0.316	0.890	0.082	0.135	0.071	0.122	1.113
S.E.D. two variety means within a temperaturee (12 d.f.)	0.217	0.274	0.195	0.521	0.185	0.091	0.145	0.069	0.718

* temperature means significant at P = 5%

** significant interaction between variety and temperature P = 1%

Table 13. The effect of late temperature treatment on monthly returns £ m^{-2}

Treatment	May	Jun	Jul	Aug	Sep	Total to Sept
Blueprint/Blueprint						
Calypso	6.78	5.57	4.14	2.62	2.47	32.62
Counter	7.03	5.87	3.51	2.37	2.18	32.88
Criterium	6.13	6.07	3.71	2.82	2.48	32.67
Mean	6.65	5.84	3.79	2.60	2.38	32.72
Blueprint/Dutch						
Calypso	6.71	5.11	4.36	2.93	3.03	33.59
Counter	6.47	5.11	3.82	2.87	2.58	33.56
Criterium	6.73	5.45	4.57	3.01	2.70	34.41
Mean	6.64	5.23	4.25	2.94	2.77	33.85
Dutch/Blueprint						
Calypso	6.40	5.67	4.06	2.81	2.57	30.87
Counter	6.93	6.10	3.65	2.51	2.17	30.42
Criterium	6.26	6.28	3.94	2.64	2.28	30.29
Mean	6.53	6.01	3.88	2.65	2.34	30.53
Dutch/Dutch						
Calypso	6.46	4.94	4.33	2.77	2.82	31.57
Counter	6.37	5.02	3.72	2.68	2.55	29.91
Criterium	5.83	5.43	4.17	2.79	2.48	31.46
Mean	6.23	5.13	4.07	2.75	2.62	30.98
S.E.D. late temp.means (3 d.f)	0.316	** 0.082	0.135	* 0.071	+ 0.122	1.113

* late temperature means significant at P = 5%
** late temperature means significant at P = 1%
\+ late temperature means significant at P = 7%

Monetary returns

Tables 12 and 13 give the monetary values calculated for this crop based on the average MAFF prices for class I and II fruit. The early temperature regimes produced a significantly higher return in February, March and April in the Blueprint regime. The late temperature regime gave improvements in return from July onwards from the Dutch regime and these were significant in August and September.

Table 14. Comparison of Return and fuel use for summer temperatures

	£ m^{-2}				MJ m^{-2}			
	Jun	Jul	Aug	Sept	Jun	Jul	Aug	Sept
Blueprint	5.93	3.84	2.63	2.36	46	46	44	61
Dutch	5.18	4.16	2.85	2.70	134	142	132	141

Taking the benefits from July onwards the Dutch regime gave an increased return of £0.88 although it should be remembered that the July difference was not statistically significant. This can then be compared to the increased fuel use required for the Dutch regime from, say, June onwards which works out at an extra 10.6 litres m^{-2} or 85p at 8p/litre. These figures would appear to indicate that using Dutch regimes for the last few months of the season will at current oil prices break even but the use of Dutch regimes before June appears to be unadviseable.

Discussion

Although the light patterns in 1987/88 were different to those experienced in 1986/87 the early results from the Dutch and Blueprint regimes were very consistent between the two years. This confirms the conclusion of 1987 that the Dutch regime in the early part of the season is unreliable if prolonged periods of poor light are experienced during the early development of the first few trusses. The lower CO_2 levels in the Dutch regime as a result of increased ventilation also occurred in both years giving reductions in fruit size.

There was some evidence of increased fruit set on one of the trusses when recorded in the summer of 1988 but there was no great compensating yield increase from the Dutch regime as occurred in 1987. The most likely explanation for this is that the average night and 24 hour temperatures in the summer of 1988 were lower than in 1987 due to the correct functioning of ventilators and the development rate was consequently slower. It is known that the development rate is linked directly with average 24 hour temperature. Although the highest yielding regime overall was the Blueprint followed by Dutch regime the result was not statistically significant and there would appear to be no yield benefit from using the Dutch regime. The monetary returns suggest that using Dutch regime from June onwards will at best break even.

The concept of using the Dutch regime in the summer to improve quality was not confirmed in 1988. There are two possible explanations for this. The reduction in summer night temperature compared to 1987 might have affected quality in some way but it is difficult to understand how this might be so as a move away from excessive night temperatures might be expected to be beneficial. More likely is the fact that in 1987 only one variety was used. The subtreatments being propagation regimes. In 1988 three varieties with different characteristics were used which behaved in different ways. For example, the quality sample assessed in week 25 for blotchy ripening a characteristic which would be apparent in normal grading, showed that Counter responded positively to the summer Dutch regime whereas Criterium and Calypso on average preferred the continuous regimes.

This interaction between temperature regimes and varieties proved to be statistically significant. Given that different varieties can behave differently it is probable that the average result shows less response to temperature regimes.

Taking an overview of all the parameters of quality assessed the Blueprint regime performed well through most of the season and on the strength of this result it would not be appropriate to recommend the Dutch regime. There was however some work done in another glasshouse at Efford in 1988 where higher night temperatures were given in the last two months of cropping. This was in effect a hybrid Dutch regime. This gave encouraging improvements in quality. The variety was Counter. The recommendation for Counter is therefore fairly clear and a Dutch or partial Dutch regime at least towards the end of the season is beneficial. For other varieties it is less easy to give a positive recommendation.

Acknowledgements

The author acknowledges the help of John Hall and the H.D.C. for sponsoring this work. Thanks are also due to R Butters for his comments.

Appendix 1

Average temperatures - weekly and monthly and fuel use

Week No.	Day B'print	Day Dutch	Night B'print	Night Dutch	24 hour B'print	24 hour Dutch	Fuel use MJm^{-2} $Week^{-1}$ B'print	Fuel use MJm^{-2} $Week^{-1}$ Dutch
50	18.4	18.5	17.2	18.0	17.6	18.2	82	89
51	18.3	19.1	17.4	19.0	17.6	19.0	49	66
52	19.0	19.3	17.6	18.3	18.1	18.7	46	61
53	18.5	19.0	16.4	18.2	17.2	18.5	43	62
Dec	18.6	19.0	17.1	18.4	17.7	18.6	55	70
1	19.6	18.6	16.2	18.1	17.5	18.3	57	70
2	20.2	18.8	16.3	17.7	17.9	18.2	60	67
3	19.5	18.2	16.1	17.7	17.4	17.8	59	67
4	20.2	18.6	16.2	17.5	17.9	17.9	71	76
Jan	19.9	18.6	16.2	17.7	17.7	18.1	62	70
5	20.7	18.8	16.2	17.6	18.2	18.1	93	86
6	20.8	18.7	16.2	17.5	18.2	18.1	71	79
7	22.0	19.0	16.5	17.9	19.1	18.4	49	58
8	21.2	18.4	16.2	17.1	18.6	17.7	113	85
Feb	21.2	18.8	16.3	17.5	18.2	18.1	82	77

Appendix 1 - continued

9	20.9	18.1	16.2	17.1	18.5	17.6	81	84
10	20.2	18.4	16.2	17.7	18.3	18.0	42	56
11	19.1	18.2	16.1	17.4	17.7	17.8	50	62
12	19.9	19.5	16.0	17.3	18.1	18.5	46	57
March	20.0	18.6	16.1	17.4	18.2	18.0	55	65
13	19.9	19.2	16.3	17.6	18.4	18.5	42	55
14	20.1	19.0	16.2	17.7	18.5	18.5	46	58
15	20.1	19.0	16.3	18.2	18.7	18.5	31	54
16	20.6	19.0	16.2	18.1	18.9	18.7	31	56
17	20.2	18.6	16.1	17.8	18.7	18.3	32	55
April	20.2	19.1	16.2	17.9	18.6	18.5	36	56
18	20.9	19.7	16.7	19.2	19.5	19.6	20	47
19	21.2	20.1	16.9	19.8	19.8	20.0	13	48
20	20.7	19.8	16.3	18.7	19.3	19.4	24	48
21	20.7	19.2	16.7	19.5	19.5	19.3	15	49
May	20.9	19.7	16.7	19.3	19.6	19.6	18	48
22	20.5	19.0	16.5	18.3	19.4	18.8	18	43
23	20.6	19.0	17.1	19.2	19.6	19.1	9	34
24	21.3	20.4	16.9	18.1	20.1	19.8	8	23
25	21.0	20.0	16.7	16.4	19.8	19.0	0	0
June	20.9	19.6	16.8	18.0	19.8	19.2	-	-

Appendix 1 - continued

26	20.2	18.6	17.0	17.6	19.4	18.4	7	16
27	20.8	19.1	17.3	18.9	19.8	19.1	10	32
28	20.9	19.2	16.9	18.7	19.7	19.0	10	33
29	20.9	19.4	17.9	19.5	20.0	19.5	9	29
30	20.9	19.2	16.8	18.5	19.7	19.0	9	33
July	20.7	19.1	17.2	18.6	19.7	19.0	9	29
31	21.8	20.6	17.7	19.2	20.5	20.1	10	32
32	21.2	19.8	17.5	19.0	19.9	19.5	11	32
33	21.3	20.0	17.3	18.7	19.9	19.5	11	31
34	20.7	18.9	17.5	18.9	19.5	19.0	13	36
Aug	21.3	19.9	17.6	18.9	20.0	19.6	11	33
35	20.7	19.0	16.9	18.4	19.2	18.8	13	33
36	21.6	20.6	16.8	18.6	19.6	19.8	16	34
37	20.9	19.0	16.5	18.0	19.1	18.6	20	39
38	20.7	19.1	16.7	18.5	18.9	18.8	13	36
Sept	21.0	19.5	16.7	18.4	19.2	19.0	31	36

Appendix 2

Outside Solar Radiation 87/88

	Week No.	MJ/Day	61-81 Long Term Mean	+/- %	
1987	50	3.2	2.5	+	28
	51	1.2	2.3	-	42
	52	2.5	2.4	+	4
	53	1.7	2.5	-	32
1988	1	2.2	2.6	-	15
	2	3.0	2.7	+	11
	3	3.1	2.8	+	11
	4	3.1	3.4	-	9
	5	4.8	3.8	+	26
	6	7.1	4.4	+	61
	7	6.6	4.9	+	35
	8	7.9	5.4	+	46
	9	9.1	7.4	+	23
	10	7.5	8.8	-	15
	11	6.2	8.4	-	26
	12	10.8	10.1	+	7
	13	11.6	10.9	+	6
	14	14.7	12.1	+	21
	15	13.2	13.7	-	4
	16	-	14.8		
	17	16.4	15.4	+	6
	18	20.1	16.6	+	21
	19	18.6	17.6	+	6
	20	21.0	19.1	+	10
	21	20.7	18.8	+	10
	22	18.0	20.3	-	11
	23	14.6	20.6	-	29

Appendix 3

Mean outside temperatures (recorded by Environmental Computer)

Week No.	Day ^0C	Night ^0C	Week No.	Day ^0C	Night ^0C
50	4.5	2.0	18	13.8	11.2
51	8.0	8.7	19	15.7	12.4
52	9.0	8.5	20	13.7	10.2
53	10.2	9.9	21	13.6	11.8
1	8.9	7.6	22	13.6	11.2
2	6.1	5.8	23	14.7	13.3
3	7.6	6.9	24	17.0	13.4
4	7.2	6.0	25	18.7	14.3
5	7.7	6.0	26	15.4	14.1
6	7.7	6.0	27	15.7	14.4
7	8.9	6.0	28	16.0	13.7
8	5.9	2.5	29	16.4	15.1
9	5.5	3.5	30	16.1	13.9
10	9.1	7.7	31	-	-
11	8.8	8.1	32	17.4	14.8
12	10.1	7.8	33	17.5	14.0
13	9.2	7.0	34	16.0	14.5
14	8.3	6.2	35	16.0	14.6
15	10.2	8.5	36	18.5	13.9
16	11.2	7.8	37	15.3	11.7
17	10.0	8.3	38	15.4	13.5
-	-	-	39	14.9	11.3

Continued

Appendix 3 - continued

24	21.2	19.9	+	7
25	19.4	19.7	-	2
26	14.9	19.0	-	22
27	19.7	20.2	-	2
28	17.4	18.5	-	6
29	16.7	18.4	-	9
30	18.4	17.8	+	3
31	16.8	17.1	-	2
32	14.6	15.6	-	6
33	16.6	15.5	+	7
34	10.8	15.4	-	30
35	15.2	14.2	+	7
36	15.5	13.7	+	13
37	11.5	12.0	-	4
38	8.5	11.4	-	25
39	8.8	9.8	-	10

Appendix 4

Date of first anthesis trusses 5-10

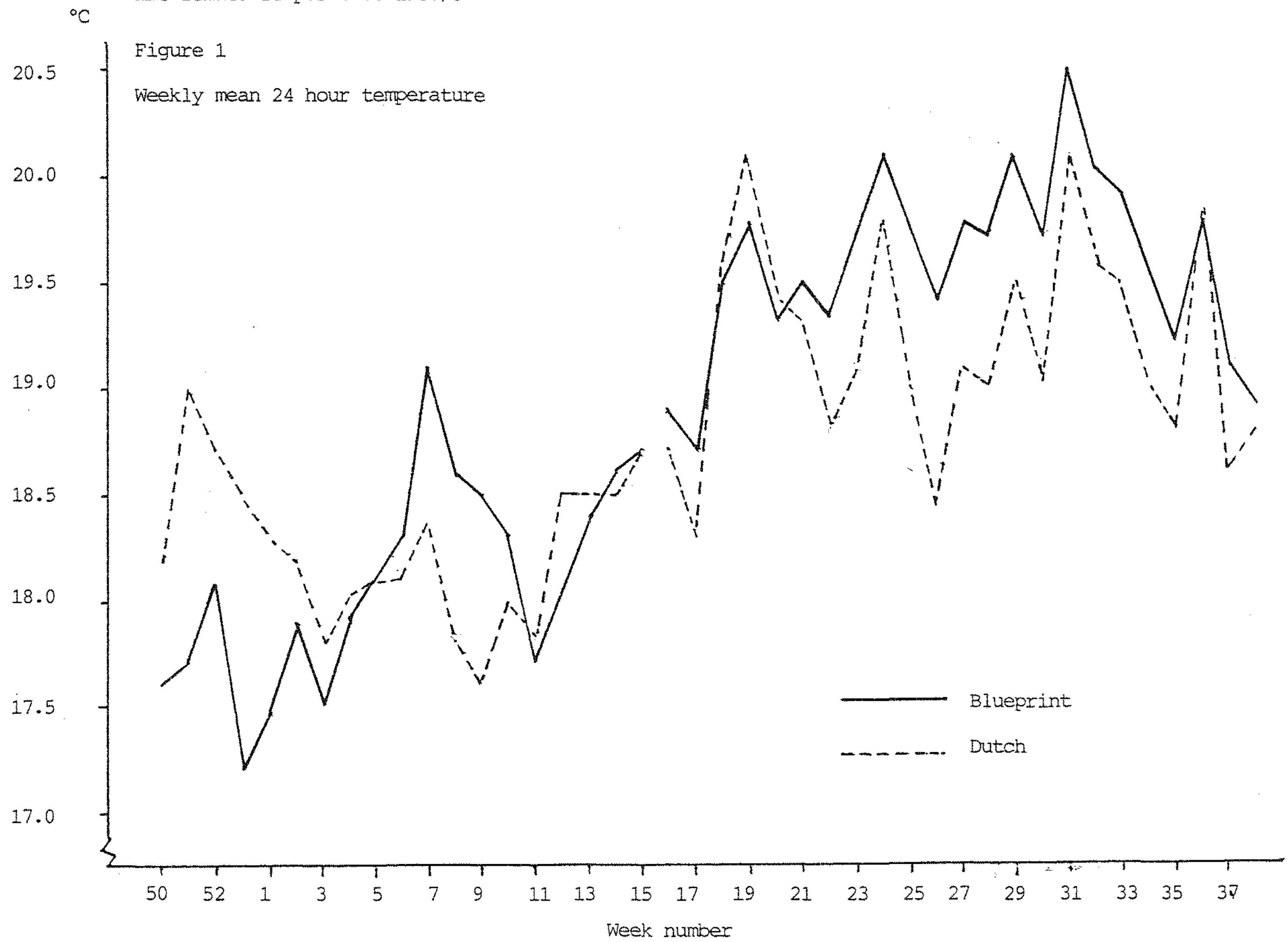
Treatment	Variety Calypso 5	6	7	8	Counter 5	6	7	8	Criterium 5	6	7	8
Blueprint	11/2	18/2	26/2	-	7/2	14/2	20/2	-	9/2	15/2	22/2	-
Dutch	9/2	17/2	26/2	-	5/2	12/2	20/2	-	8/2	15/2	23/2	-

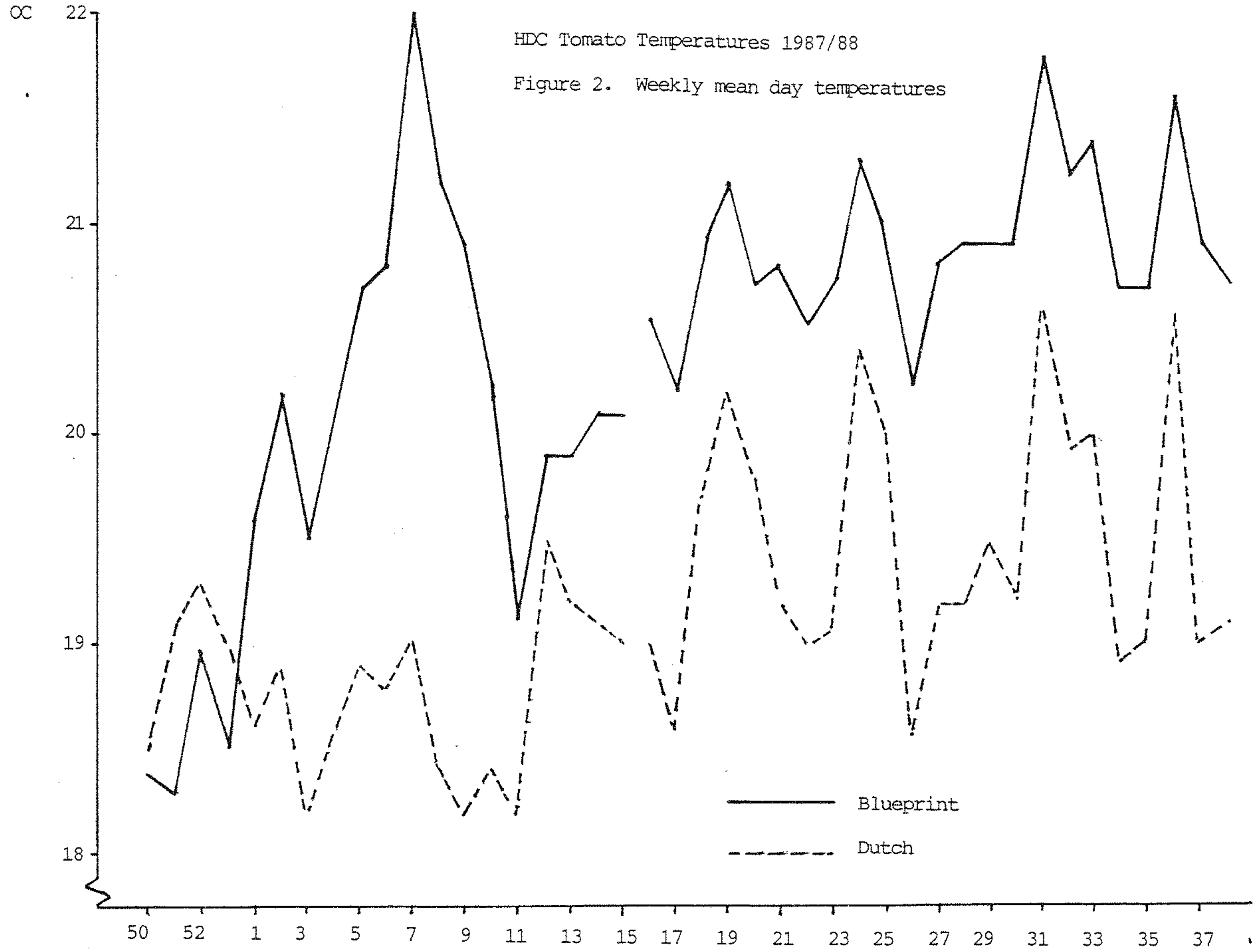
	Calypso 9	10	Counter 9	10	Criterium 9	10
Blueprint	9/3	18/3	7/3	15/3	8/3	15/3
Dutch	12/3	21/3	7/3	15/3	10/3	18/3

HDC Tomato Temperature 1987/8

Figure 1

Weekly mean 24 hour temperature



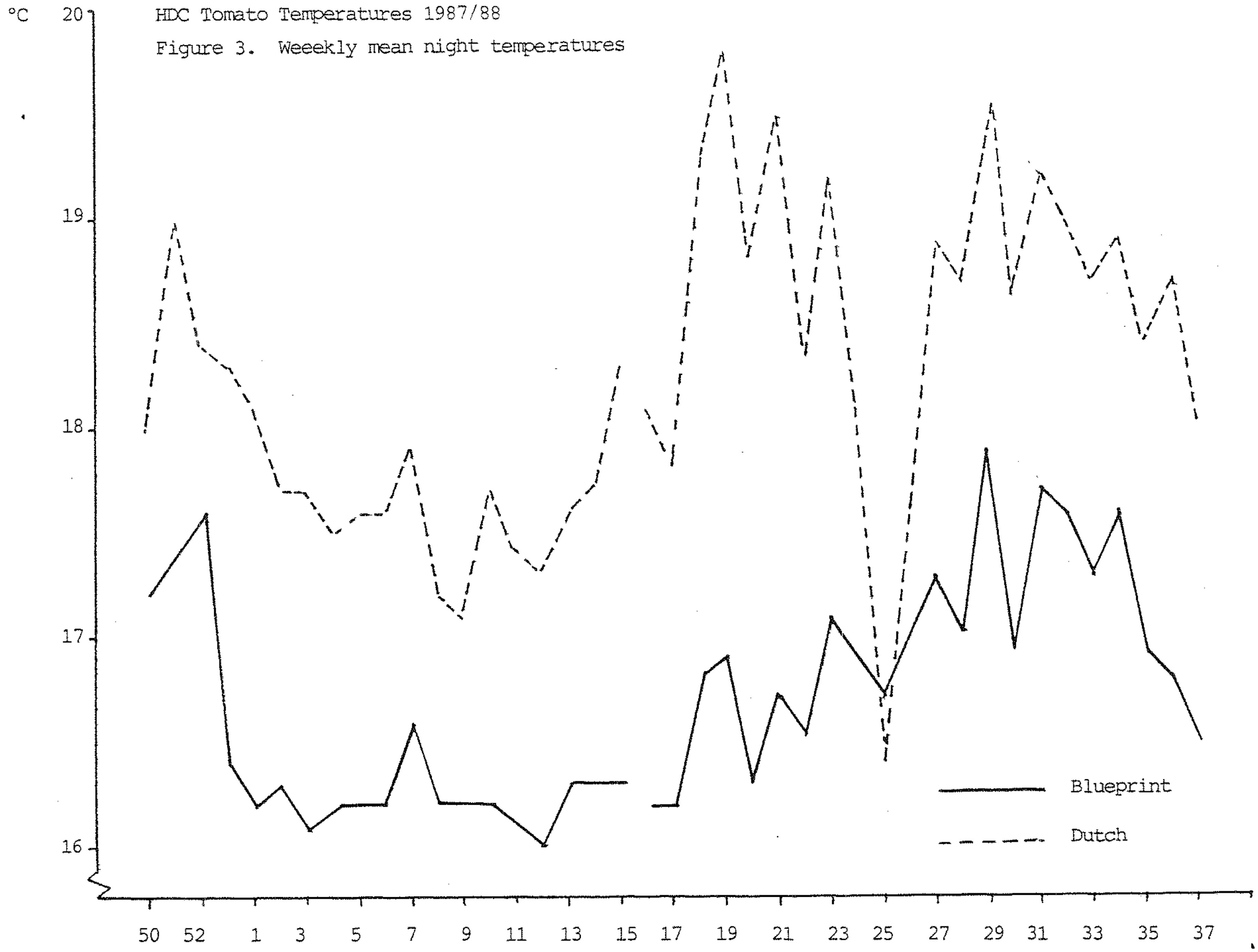


HDC Tomato Temperatures 1987/88

Figure 2. Weekly mean day temperatures

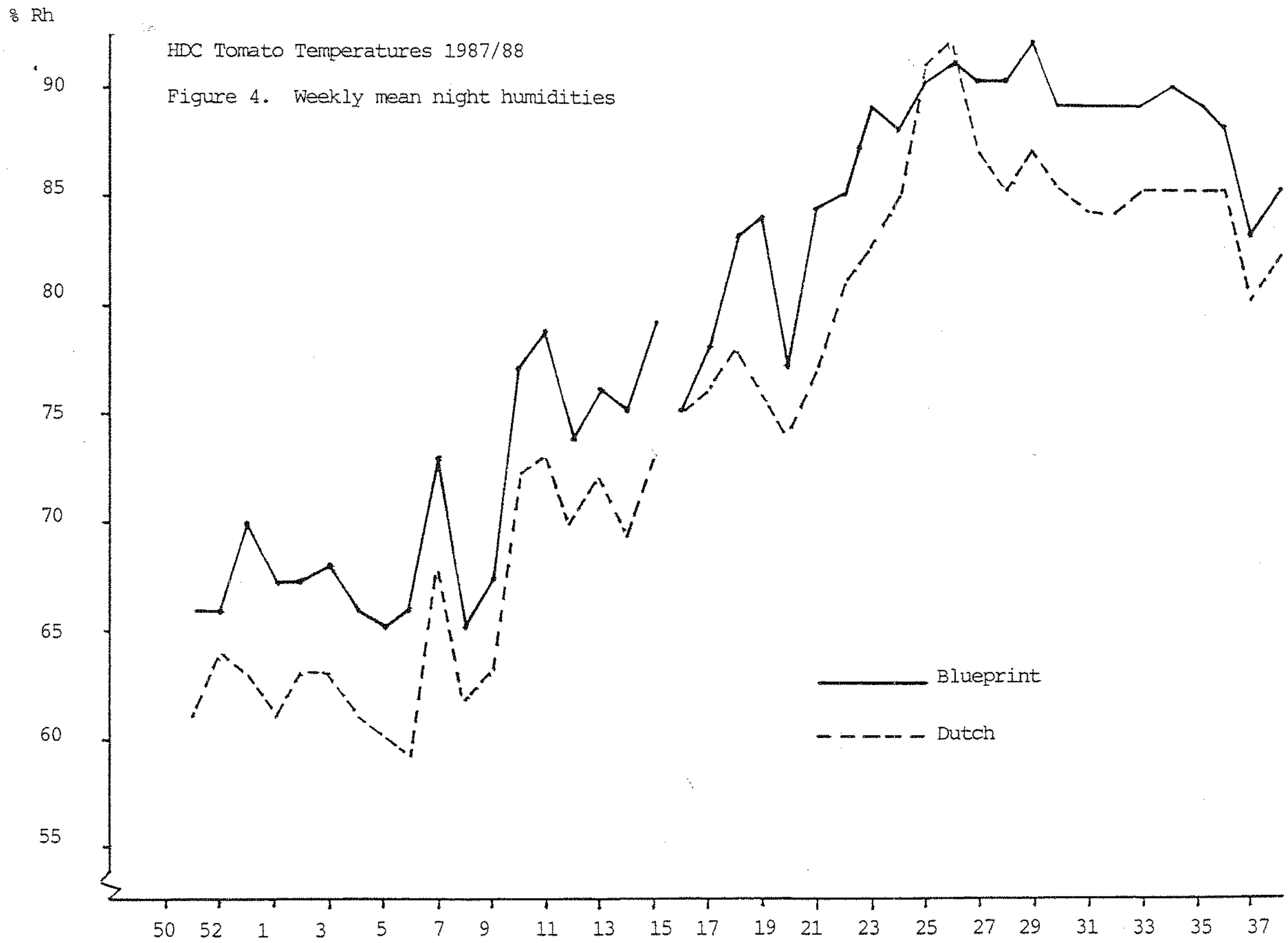
HDC Tomato Temperatures 1987/88

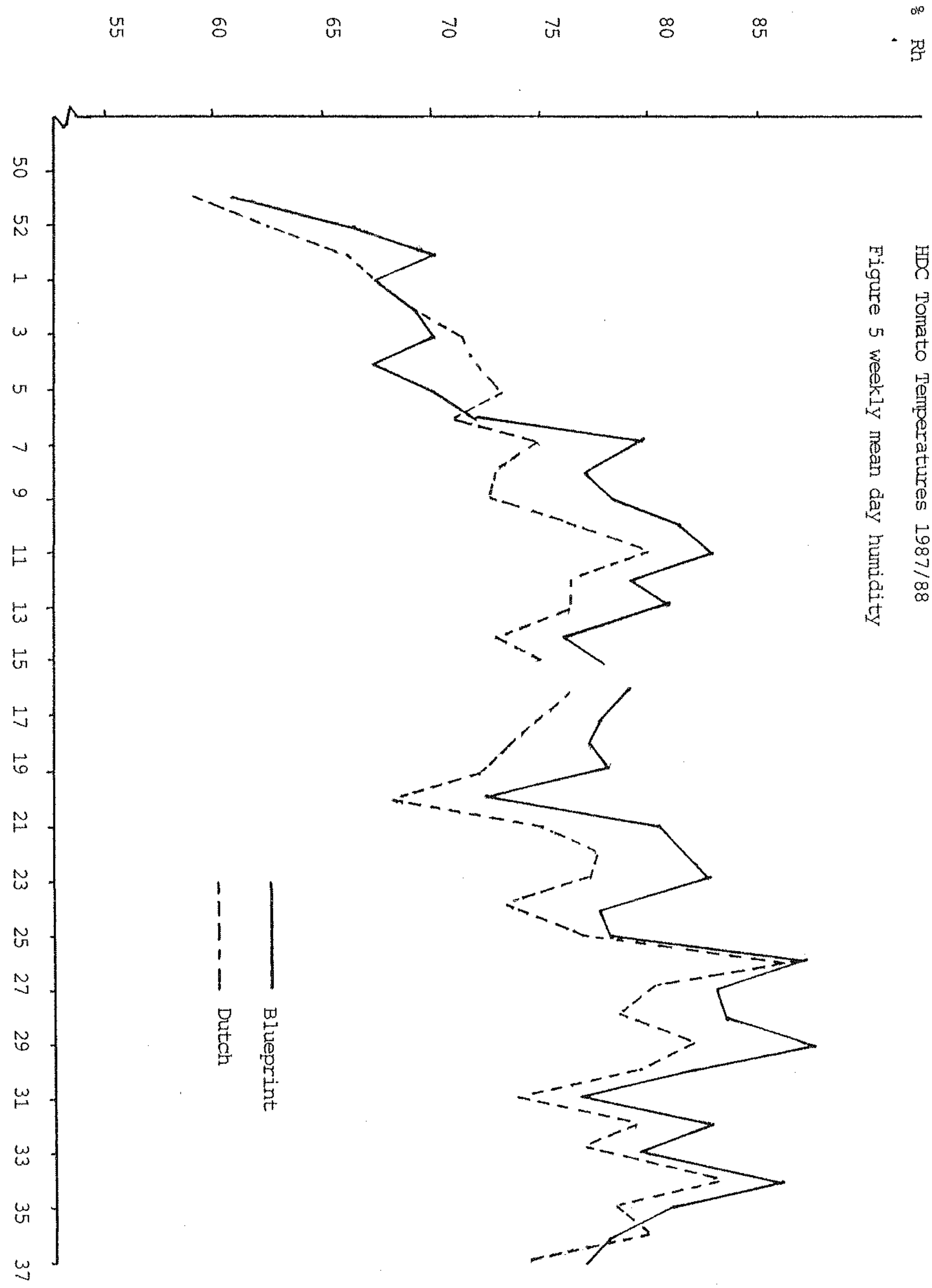
Figure 3. Weeekly mean night temperatures



HDC Tomato Temperatures 1987/88

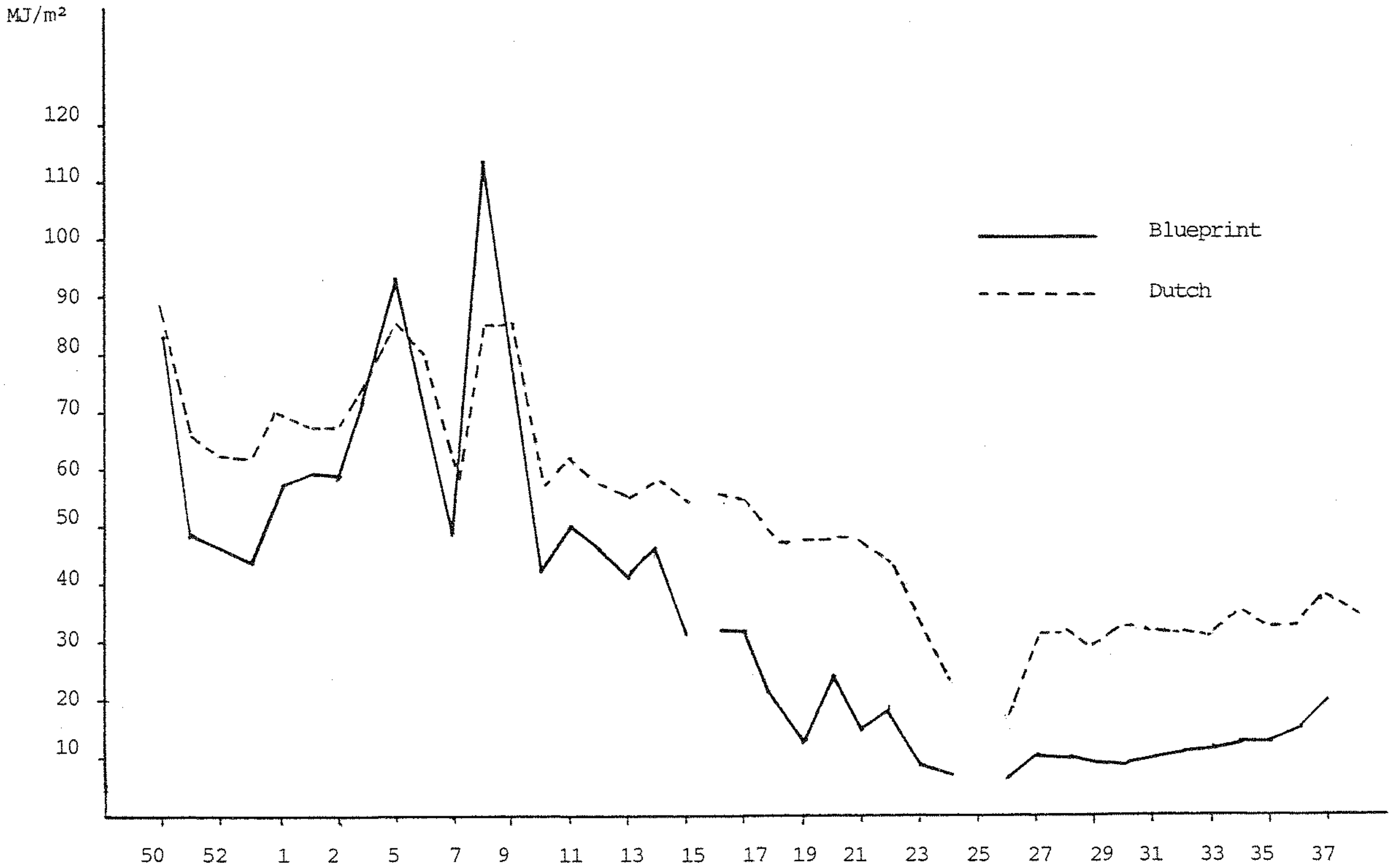
Figure 4. Weekly mean night humidities




HDC Tomato Temperatures 1987/88
Figure 5 weekly mean day humidity
% Rh
55
60
65
70
75
80
85
50
52
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
Blueprint
Dutch

HDC Tomato Temperatures

Figure 6. Weekly fuel use MJ/M²/Week



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

PROPOSAL

1. **Title of project** PC/2/87.

Tomato temperature regimes.

2. Background

Temperature recommendations in the U.K. have been developed over many years with the main emphasis recently on fuel economy. Crop performance has always been taken into account when assessing energy conservation methods both in relation to yield and crop value. Distribution of yield through the season has been an important consideration since the traditional price pattern has favoured early production with mid-season and late prices being much more speculative.

Dutch growers have enjoyed some advantage in energy prices until recently and have had cheaper carbon dioxide available by extraction from natural gas fired boilers. There has also been much greater investment in Holland in new glasshouses which are much better sealed for enery conservation but as a consequence give rise to more humidity related problems. Current Dutch regimes have humidity control as a major priority, therefore, but somewhat paradoxically this results in a substantial increase in energy use (and CO_2).

The Dutch regime features lower ventilation temperatures and extensive use of minimum pipe heat for humidity control. It also uses a higher night temperature and lower day temperature than normal U.K. practice. The average 24 hour temperature is considered to be the important criterion of crop development.

The higher night temperature is of potential advantage in energy use if a thermal screen is used and there may be some fruit quality benefits. The lower day temperature may have some advantage in plant development and may be less important than has hitherto been the case for fruit setting with the development of new easier setting varieties.

3. Objective of this project

To compare current Dutch tomato temperature regimes with those developed in the U.K. for early, long-season crops. Information will be obtained on yields, fruit quality and production costs in order to provide U.K. growers with advice on the most cost effective regime <u>for their circumstances</u>.

4. Potential benefit to the Industry

If reported yield increases from the Dutch regime are confirmed, this would result in an increase of approximately 6,100 tons of U.K. fruit from the early crop (506 acres at 12 tons/acre). At current values this would represent £2.5 - 3.0 millions.

Without the use of thermal screens, this figure would have to be abated by the cost of increase energy use of perhaps £900,000 (additional 6,000 gals. oil per acre at 30p).

If yield increases are not realised and energy costs rise again to say 50p/gal, adoption of the Dutch regime would cost U.K. growers approximately £1,5M.

5. Closely related work already completed or in progress

Temperature recommendations have been developed in the U.K. over many years, with the main emphasis on fuel economy. The Dutch regime is backed by relatively little experimental evidence. Two experimental crops have been grown in the soil and none in substrates and results did not include records of fuel and CO_2 use. Commercial experience suggests the regime will give high total yields, probably lower early yields and a substantial increase in fuel use.

6. Description of the work

A replicated experiment will be conducted at Efford EHS in 1986/87 on an October sown crop grown in rockwool. Four treatments are proposed.

a) Current ADAS "Blueprint".

b) Dutch regime. 17.5°C night, 18°C day, 19°C ventilation.

c) Combination regime, i.e., Dutch regime in mornings and ADAS Blueprint in afternoons.

d) ADAS Blueprint but with lower ventilation temperatures.

CO_2 control will be similar in all treatments, to a reasonable level achievable with pure CO_2.

Records will include yield, fruit size, detailed assessments of fruit quality and shelf-life (linked to HDC proposal on Tomato Fruit Quality), environmental records, fuel, CO_2 use and plant performance (growth rate, leaf area, nutrition).

7. Commencement date and duration

Commencing 1.12.86, duration 2 years.

8. Staff responsibilities

Project leader: G Hayman

Other staff:

9. Location

Efford EHS.

10. Costs

A funding level of £35,000 p.a. has been agreed.

11. Payment

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

Project year	1.	2	3
	£35K	£35K	

Quarter/Year	1987	1988	1989
1	11,667	8,750	
2	8,750	8,750	
3	8,750	8,750	
4	8,750	5,833	

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....[illegible]..........

Position.......Chief Executive....

Date..................7.7.87.....

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 ....

Agreed by
on behalf of
customer date ....

CONTRACT, TERMS AND CONDITIONS AND SCHEDULE

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

CONTRACT FOR THE SUPPLY OF R & D AND SERVICING WORK

This form sets out the work which it is proposed that the Ministry of Agriculture, Fisheries and Food should do for you. It is subject to the conditions printed in the Terms and Conditions and Schedule attached. If you agree the terms please sign and return both copies of the forms. One set will be returned to you. The offer will remain open for 30 days from its date.

1. Name and address of customer

   ....

   ....

2. Name and address of MAFF/ADAS Unit

   Name/Title of Unit ....

   Address ....

   ....

3. Title of work proposed

   ....

   ....

   See attached schedule for full details

4. Price and payment arrangements (including payment dates and VAT payments)

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....

....

....

Proposed completion date ....

5. Name or title of person in charge for the customer and MAFF

MAFF Contract Manager ....

Address if different from 2 above ....

....

Customer's contact point ....

Address if different from 1 above ....

....

6. Miscellaneous

....

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....

....

7. Signed by | Agreed by

on behalf of MAFF .... | on behalf of customer ....

Dated .... | Dated ....