HORTICULTURE RESEARCH INTERNATIONAL

EFFORD

Report to:

Horticultural Development Council
18 Lavant Street
PETERSFIELD
Hampshire GU32 3EW

Tel: 0730 263736
Fax: 0730 265394

HRI Contract Manager:

Miss M A Scott
HRI Efford
LYMINGTON
Hampshire SO41 0LZ

Tel: 0590 673341
Fax: 0590 671553

Period of Investigation: November 1992 - October 1993
Date of issue of report: April 1994
No. of pages in report: Forty Three
No. of copies of report: Six
This is copy no. 3: Issued to Horticultural Development Council

FINAL CONTRACT REPORT

Tomatoes: Irrigation Regimes for a Long Season Rockwool Crop 1992/93

HDC PC82

PRINCIPAL WORKERS

HRI EFFORD

Dr D J Hand BSc (Hons), PhD, M.I. Hort	Technical Officer
Mr M Fussell BSc (Hons) (Author of report)	Scientific Officer
Mrs S Foster	Scientific Officer
Miss J Basham	Assistant Scientific Officer
Mr M Wainwright, BSc	Assistant Scientific Officer
Mr C Vigor	Nursery Staff
Mr M Verran	Nursery Staff
Mr S Stagg	Nursery Staff
Mr M Reay	Computer Systems, Maintenance

HRI LITTLEHAMPTON

Mr R H Edmondson MSc	Statistician

AUTHENTIFICATION

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

Signature ..Margaret A. Scott.....

Margaret Scott
Deputy Head of Station

Date ..29/4/94.....

Report Authorised by .....
Signature

M R Shipway
Head of Station

HRI Efford
LYMINGTON
Hants
SO41 0LZ

Date 29/4/94.....

CONTENTS

	Page
Acknowledgements	1
Relevance to Growers and Practical Application	2
Experimental Section	3
Summary	3
Introduction	4
Objectives	4
Materials and Methods	5
Site Details	5
Treatments	5
Cultural Techniques	6
Assessments	7
Fruit Quality Assessment Methods	7
Disorder Assessments	7
Shelf-life Assessments and Chemical Analysis	8
Experimental Design and Explanation of Statistical Terms	8
Results	10
Plant Growth and Development	10
Yield and Gradeout	10
Fruit Quality	10
Levels of Physical Disorders	10
Shelf-life	11
Internal Composition	11
Run-off Percentages	11
Applied Volumes and Slab Environment	11
Discussion	24
Conclusions	25

Appendices

		Page
Appendix I:	Trial Plan	27
Appendix II:	Crop Diary	28
Appendix III:	Effect of irrigation regimes on the date of first anthesis and first pick on trusses 1-10	30
Appendix IV:	Effect of irrigation regimes, and substrate on Total Yield	31
Appendix V:	Effect of irrigation regime, growing system and substrate on Marketable Yield	32
Appendix VI:	Effect of irrigation regime, growing system and substrate on Percentage Class I fruit	33
Appendix VII:	Effect of irrigation regime, growing system and substrate on Percentage Class II fruit	34
Appendix VIII:	Effect of irrigation regime, growing system and substrate on Percentage waste fruit	35
Appendix IX:	Effect of irrigation regime, growing system and substrate on Percentage Class I fruit in grade C	36
Appendix X:	Effect of irrigation regime, growing system and substrate on Percentage Class I fruit in grade D	37
Appendix XI:	Effect of irrigation regime, growing system and substrate on Percentage Class I fruit in grade E	38
Appendix XII:	Effect of irrigation regimes on levels of Gold Spot	39
Appendix XIII:	Effect of irrigation regimes on the Percentage soluble solids content of fruit	40
Appendix XIV:	Effect of irrigation regimes on the Percentage Dry Matter content of fruit.	41
Appendix XV:	Contract Terms and Conditions	42

ANNUAL REPORT APRIL 1994
HDC PC82

TOMATOES: IRRIGATION REGIMES FOR A LONG SEASON ROCKWOOL CROP

Dr D J Hand
M Fussell

HRI Efford

Co-ordinator: Mr G Hayman

Commenced: November 1992

Completed: October 1993

Key Words: Tomato, Irrigation regimes, Rockwool

ACKNOWLEDGEMENTS

The assistance of HDC Co-ordinator Mr Gerry Hayman with the planning of this trial is gratefully acknowledged. Dr Nigel Dungey also provided valuable advice.

RELEVANCE TO GROWERS AND PRACTICAL APPLICATION

The principal aim of this study was to investigate whether extra irrigation rounds applied either early in the morning (0800, 0900 and 1000h), late afternoon (1500, 1600 and 1700h) or around midnight (2300, 2400 and 0100h) resulted in increased yield as was the case in 1991/92 (PC23c) when additional irrigation rounds were applied around midnight. In the case of the latter experiment it was unclear whether the yield increase was a function of the time of application or merely a response to the increased total volume.

The trial reported here clearly demonstrated, however, that additional waterings imposed on a standard irrigation regime of 150ml per plant/100Jcm^2 had no significant yield benefit. The 'night' watering treatment produced a final yield of 50.50kgm^{-2} compared with 48.93kgm^{-2} produced by the 'control' where no extra waterings were applied.

Extra water had the effect of reducing soluble solids and dry matter content of fruit early in the season and reducing levels of Gold Spot.

The trial also sought to investigate whether different growing systems and medias behaved differently under the different irrigation regimes. Since the irrigation regimes had little effect overall, it was not surprising that all sub-treatments behaved similarly. While it was not the intention of the trial to compare growing systems and medias directly some interesting results were obtained.

The V-System performed as well as the Double Rows for most of the season, demonstrating that reduced root volume does not result in reduced yield so long as plants are provided with sufficient nutrients and water. Higher run-off percentages were recorded for the V-System.

Small differences in yield were found between substrates. The most water retentive, Grodan rockwool, resulted in slightly higher yield than the less water retentive Cultilene rockwool and glasswool. Higher run-off percentages were associated with the Cultilene crops suggesting that a more frequent irrigation regime with smaller volumes per application might have suited them better. However, it is not suggested that the irrigation regimes evaluated here were in any way 'optimal' for the substrates included in the study.

EXPERIMENTAL SECTION

SUMMARY

Work done at Efford during the 1992/93 cropping season investigated the effects of extra waterings and their timing on the yield and fruit quality of a long season tomato crop *(Lycopersicon esculentum Mill)*. Two growing systems and three substrates were included as sub-treatments to determine any differences in behaviour to the irrigation regimes.

A crop of Calypso was sown on 3 November 1992. Propagation and subsequent early growth were standard throughout and followed current commercial practice. Irrigation regimes commenced on 14 February. Three extra waterings of 100 ml per round/per plant were applied each day at 2300, 2400 and 0100 h for the night watering treatment, at 0800, 0900 and 1000 h for the morning treatment and at 1500, 1600 and 1700 h for the afternoon treatment.

Neither the increased volume of the extra waterings or their timing had any significant effect on yield or percentage Class 1 fruit.

The extra waterings did, however, result in reduced levels of soluble solids and dry matter in fruit early in the season and also reduced levels of Gold Spot.

There were no interactions between growing systems, medias and irrigation regimes. The V-System yields were as high as those for the Double Rows for most of the season. Percentage run-off was higher for the V-System. Grodan rockwool yielded slightly higher than the Cultilene rockwool or glasswool and produced much lower percentage run-off.

INTRODUCTION

Work done at HRI Efford during 1991-1992 quantified the effect of irrigation frequency by day in combination with the presence or absence of night waterings and the use of reduced rockwool volumes, namely the V-System.

The presence of night waterings had the effect of increasing yield by 1.59 kgm^{-2} (10.52%) to the end of May and 3.46 kgm^{-2} (6.85%) to the end of September in the 1991/1992 season. However, it was not possible from that trial to separate the effects of additional volume (3 applications of 100mls per day) from the timing of the applications.

Many growers are now using the V-System of training tomato plants which reduces the volume of substrate available to the roots. Irrigation regimes which work well for the conventional Double Row growing system may not be the most suitable for the V-System. In the 1991/1992 HDC Irrigation trial the Double Rows outyielded the V-System by 2.93 kgm^{-2} (5.79%) to the end of September.

OBJECTIVES

To determine the effects, if any, of time of application of extra volumes of feed solution on tomato plant development, yield and fruit quality. To investigate whether the choice of substrate and growing system result in any differences in plant performance and the amount of feed solution running to waste under the different irrigation regimes.

MATERIALS AND METHODS

Site Details

The trial was done at HRI Efford utilising the F-Block facility. The layout of the trial is illustrated in Appendix I, page 27.

Treatments

The main treatments comprised four irrigation regimes.

1. No extra watering.
   A 'standard regime' of 150 ml per plant (200 ml early season) / 100 J cm^{-2} incident radiation as measured by an externally mounted Kipp solarimeter.

2. Extra water at night.
   As (1) above with three additional waterings of 100 ml/plant at 23.00 24.00 and 01.00 h.

3. Extra water in the morning.
   As (1) above with three additional waterings of 100 ml/plant at 08.00, 09.00 and 10.00 h.

4. Extra water in the afternoon.
   As with (1) above with three additional waterings of 100ml/plant at 15.00, 16.00 and 17.00 h.

Sub treatments.

(substrate x growing system)

(i) Grodan Rockwool
(ii) Cultilene Rockwool
(iii) Cultilene Glasswool

each of the above substrates were tested as:

(i) Double Row
(ii) V-System

Cultural Techniques

Seeds of tomato *(Lycopersicon esculentum Mill)* cv Calypso were sown on 3 November 1992, in rockwool multiblocks (40 x 40 x 40mm) which had been wetted up the day before using a feed solution with a pH of 5.0 and an EC of 1,500 μS. Following germination the EC was raised to 2,500 μS coincident with expansion of the cotyledons. Prior to blocking on, ten days after sowing, the 0.65 litre rockwool blocks were wetted up with a feed of pH 5.0 and an EC of 2,500 μS, the aim being to achieve a stable block pH of circa 6.0.

From blocking on to the time taken for the third true leaf to reach 10mm in length, the EC of the applied feed was raised from 2,500 to 3,500 μS. The EC was then raised to 5,000 μS in preparation for slab contact on 4 January 1993.

Modified 'Blueprint' temperatures were applied throughout propagation.

The 'Blueprint regime'

Stage		**Target Air Temperatures °C**		
		Day	**Night**	**Vent**
0.	**Sowing to Germination**	24	24	26
1.	**Germination to blocking on**	20	20	24
2.	**Blocking on to 1st visible bud**	20	16	24

The CO_2 level in the glasshouse was raised from ambient to a target 1,000 vpm (sunrise to sunset; using pure CO_2).

V-System plants were knocked over on 14 December and plants were strung to a 3 m crop wire and layered on reaching wire height. The initial plant density was 2.62 plants/m^2 or 10,600 plants/acre. Sideshoots were taken from one in four plants in week 11 to produce a final population at 3.27 plants/m^2 or 13,250 plants/acre. In all respects crop management followed best commercial practice. Full details of the crop diary, including pest disease control are listed in Appendix II, pages 28-29.

Assessments

The following records were taken during the course of the trial.

- Graded and total marketable yield, percentage Class I, II and Waste fruit.
- Date of first anthesis, first fruit pick, number of fruits set and number marketable on trusses 1-10 for four plants per plot.
- Severity of fruit physical disorders.
- Shelf-life potential of fruit
- Measurement of applied and run-off volumes for all treatments.
- Routine analysis of applied and slab solution for nutritional content.
- Daily monitoring of applied and slab solution pH and EC.
- Full monitoring of the glasshouse aerial environment.
- Photographic record of the crop.

Fruit Quality Assessment Methods

Disorder Assessments

Ten fruit were sampled at random from each plot and each fruit assessed for the following disorders.

Boxiness (hollow fruit)
Slab-sidedness
Ribbing
Nippling
Netting (fine net cracking)
Concentric cracking
Gold spot (calyx end)
Gold Marbling (flecking - blossom end)
Red Noses
Blotchy ripening
Laddering (Gooseberry veining)
Squat fruit

Disorders were scored from 0 (none) - 4 (severe) for each of the 10 fruit and a mean score calculated for each plot.

Shelf-life Assessments and Chemical Analysis

Fruit were sampled at ATB Colour stage 4. Where possible 10 Class 1, Grade D fruit were chosen. However when fruit picks were small or when fruit did not fulfil the above criteria, fewer fruit were selected or Size C or E fruit included.

Tomatoes were passed through a handling simulator (500-600mm drop) and placed in plastic trays in the shelf life room where they remained for 6 days. The shelf life room was maintained at around 20°C and 50-60% Relative Humidity, with 12 hours of fluorescent lighting per day.

The sample of fruit for each plot was weighed at the beginning and the end of the shelf life period and the percentage weight loss calculated for the plot.

At the end of the shelf life period, the calyx was removed from each individual fruit before measurement of its compression (mm) under a 1kg load in a firmness meter. A mean compression was calculated for each plot.

Fruit were taken at the end of the shelf-life assessments and divided for dry weight determination and acidity and soluble solids determinations.

% Dry Weight: For each plot, quarters from each of 5 fruit were placed in a tray, weighed and then dried in an oven at 60°C for 3 days. The samples of fruit were weighed again and the percentage dry matter calculated taking into account the percentage weight loss during shelf-life.

% Soluble Solids: The remaining tomatoes, not used in the dry matter determinations, were placed in plastic bags (one for each plot) and frozen. After thawing, fruit was pulped by hand and filtered for 2 hours to separate the juice. Two measurements of percentage soluble solids of the juice were made for each plot using a sugar refractometer (range 0-10% Brix) and an average taken. Readings were adjusted according to the temperature of the solution.

Acidity: This was determined by dissolving 0.38g tri-sodium orthophosphate $Na_3PO_4.12H_2O$) in 20ml filtered juice and after 10 minutes measuring the endpoint pH with a hand held pH meter.

Experimental Design and Explanation of Statistical Terms

The 24 treatments (4 irrigation regimes x 2 growing systems x 3 substrates) each comprised two replicates. The 48 plots were arranged in a balanced row and column design (refer to trial plan, Appendix I). A full analysis of variance was carried out and hence differences between treatments were assigned statistical significance.

Throughout the main body of this report and selected appendices a number of statistical terms are referred to; these are:-

SED = The standard error of the difference when comparing two means in that column of data

A statistical term easier to interpret:

LSD 5% = The least (minimum) difference when comparing two means within a given column that is required for the means to be statistically different.

N.S = Not significant

* = <0.05, i.e. the probability of this result occurring by chance is equal to or less than 1 in 20 ($0.05=5\%$).

** = $P<0.01$, i.e. the probability of this result occurring by chance is equal to or less than 1 in 100 ($0.01=1\%$).

*** = $P<0.001$, i.e. the probability of this result occurring by chance is equal to or less than 1 in 1000 ($0.001=0.1\%$).

RESULTS

Plant Growth and Development

The treatments generally had no effect on the time taken for the plants to reach first anthesis on trusses 1 - 10. The time taken for the fruit to develop was similarly unaffected by the treatments. Date of first anthesis and first pick on trusses 1 - 10 are listed in Appendix III, page 30.

There were no significant differences in the number of fruit set or the number of marketable fruit on trusses 1 - 10 between the irrigation regimes. However, more fruit per truss were set and more marketable for the Double Rows than the V-System (Table 1, page 12).

Yield and Gradeout

The night watering treatment produced the highest yield, 17.33 kgm^{-2} to the end of May and 50.5 kgm^{-2} to the end of September but differences between treatments were not significant (Tables 2 and 3, page 13). The Double Rows produced higher yield than the V-System in March but for the rest of the season yields were similar (Table 4, page 14). There was a slight difference in yield between the medias. Grodan rockwool yielded consistently more than Cultilene rockwool and Cultilene glasswool yielded the lowest throughout the season but differences were only significant in April and July (Table 5, page 14). Overall differences to end of September between substrates were no bigger than the differences between irrigation regimes.

The gradeout figures were similar for all treatments and sub-treatments. (Appendices IV-XI, pages 31-38).

Fruit Quality

Levels of Physical Disorders

Fruit shape, ripening disorders and other disorders were generally unaffected by the treatments and sub-treatments. The only apparent effect of the extra waterings was to reduce levels of Gold Spot (Fig 1, page 15). The lowest levels of Gold Spot were recorded in the extra water at night treatment. However differences were not significant. (See Appendix XII, page 39).

Shelf-life

The treatments and sub-treatments had little effect on fruit softness or weight loss after 6 days storage.

Internal Composition

The 'no extra' water treatment resulted in fruit with higher levels of soluble solids and higher percentage dry matter for the first half of the season (Figures 2 and 3, pages 16 and 17). However, the effect did not persist throughout the whole season and differences were not generally statistically significant. The data for soluble solids and dry matter content are listed with levels of statistical significance in Appendices XIII and XIV, pages 40 and 41.

Run-off Percentages

For the early part of the season (up to week 25) the no extra waterings treatments produced the smallest percentage run-off figures (Figure 4, page 18). However, this effect did not persist. Unfortunately problems were encountered recording run-off data from the extra water at night treatment and that data is therefore not presented.

There were marked differences in the percentage run-off from the 2 growing systems. The V-System resulted in consistently higher run-off (Figure 5, page 19). Similarly, there were marked difference between substrates. Grodan rockwool resulted in lower run-off than the Cultilene rockwool and glasswool. While differences between the Cultilene medias were negligible from week 18 onwards, before that the glasswool media produced much higher run-off (Fig 6, page 20).

Applied Volumes and Slab Environment

Figure 7, page 21, shows the average volume of feed applied per plant per week for each treatment as measured by flow meters in the irrigation line. The projected volume, based upon the number of waterings triggered by light (excluding extra waterings) and the intended volume of each watering, is also plotted. It can be seen that similar volumes were applied on all treatments except that slightly lower volumes were applied to the no extra watering treatment as planned, and that the extra water night treatment received too much water up until week 22. These differences are reflected in the slab environment. The conductivity in Grodan slabs on the Double Row system was consistently higher for the no extra watering treatment and lower for the extra water at night treatment, particularly early in the season (Figure 8, page 22). The extra water at night treatment slabs were more acidic than the others, closer to the pH of the applied feed (Figure 9, page 23). Differences in slab environment between growing systems and medias were not consistent.

Table 1 **Effect of irrigation regime and growing system on the average number of fruit set and marketable on trusses 1-10**

Irrigation regime	Number set	Number marketable
No extra watering	9.14	7.92
3 x 100mls @ 23, 24, 01 h	9.56	8.17
3 x 100mls @ 08, 09, 10 h	9.53	8.05
3 x 100mls @ 08, 09, 10 h	9.53	8.05
3 x 100mls @ 15, 16, 17 h	9.22	7.61
SED (3 d.f)	*0.134*	*0.277*
LSD	*0.315*	*0.652*
Significance	*N.S.*	*N.S.*

Growing system	Number set	Number marketable
Double Row	9.49	8.13
V-System	9.24	7.74
SED (3 d.f)	*0.061*	0.073
LSD	*0.144*	0.172
Significance	*	*

Table 2 Effect of irrigation regime on total yield, percentage Class I fruit and grade out to the end of May.

Irrigation regime	Total yield kg/m²	% Class I fruit	% Class I fruit in size grade C >57mm	D 47-57mm	E 40-47mm
No extra waterings	16.65	91.0	14.5	74.4	10.5
3 x 100mls @ 23, 24, 01 h	17.33	90.6	16.1	74.0	9.3
3 x 100mls @ 08, 09, 10 h	16.59	90.6	15.3	73.6	10.5
3 x 100mls @ 15, 16, 17 h	16.55	90.4	13.8	75.0	10.5
SED (3 d.f)	*0.94*	*0.40*	*3.85*	*2.53*	*1.36*
LSD (5%)	*2.21*	*0.94*	*9.06*	*5.95*	*3.20*
Significance	*N.S*	*N.S*	*N.S*	*N.S*	*N.S.*

Table 3 Effect of irrigation regime on total yield, percentage Class I fruit and grade out to the end of September.

Irrigation regime	Total yield kg/m²	% Class I fruit	% Class I fruit in size grade C >57mm	D 47-57mm	E 40-47mm
No extra waterings	48.93	89.2	17.9	72.6	8.8
3 x 100mls @ 23, 24, 01 h	50.50	89.3	17.8	72.4	9.0
3 x 100mls @ 08, 09, 10 h	49.88	90.3	17.1	73.1	9.0
3 x 100mls @ 15, 16, 17 h	47.95	89.9	17.1	72.9	9.3
SED (3 d.f)	*0.65*	*0.88*	*3.07*	*1.99*	*1.15*
LSD (5%)	*1.52*	*2.07*	*7.22*	*4.68*	*2.70*
Significance	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*

Table 4 Effect of growing system on total yield (kgm^{-2})

Growing System	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Double Row	2.58	5.87	8.57	9.05	9.08	7.68	6.92	49.74
V-System	2.19	5.54	8.81	9.03	9.05	7.60	6.67	48.88
SED (3 d.f)	*0.089*	*0.125*	*0.158*	*0.145*	*0.112*	*0.068*	*0.027*	*0.513*
LSD 5%	*0.209*	*0.294*	*0.372*	*0.341*	*0.264*	*0.160*	*0.064*	*1.207*
Significance	*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	**	*N.S.*

Table 5 Effect of substrate on total yield (kgm^{-2})

Substrate	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Grodan rockwool	2.54	5.83	8.84	9.09	9.25	7.78	6.89	50.22
Cultilene rockwool	2.29	5.74	8.63	9.10	9.04	7.63	6.83	49.26
Cultilene glasswool	3.32	5.55	8.59	8.94	8.90	7.50	6.66	48.47
SED (16 d.f)	*0.103*	*0.084*	*0.168*	*0.173*	*0.130*	*0.133*	*0.169*	*0.664*
LSD (5%)	*0.214*	*0.174*	*0.349*	*0.359*	*0.270*	*0.276*	*0.351*	*1.378*
Significance	*N.S.*	*	*N.S.*	*N.S.*	*	*N.S.*	*N.S.*	*N.S.*

Figure 1.

Effect of irrigation regime on levels of Gold Spot

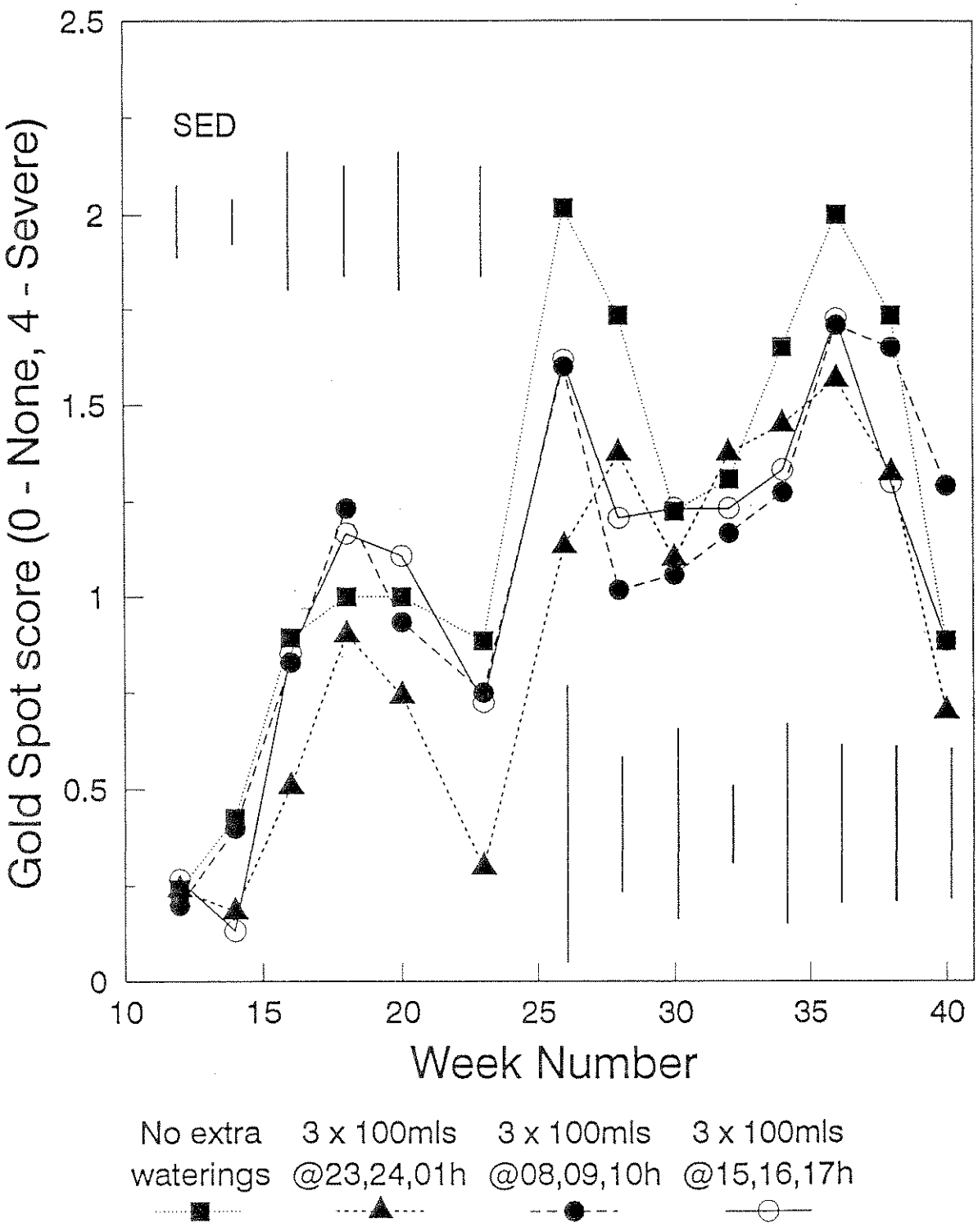


Figure 2.

Effect of irrigation regime on levels of soluble solids in fruit

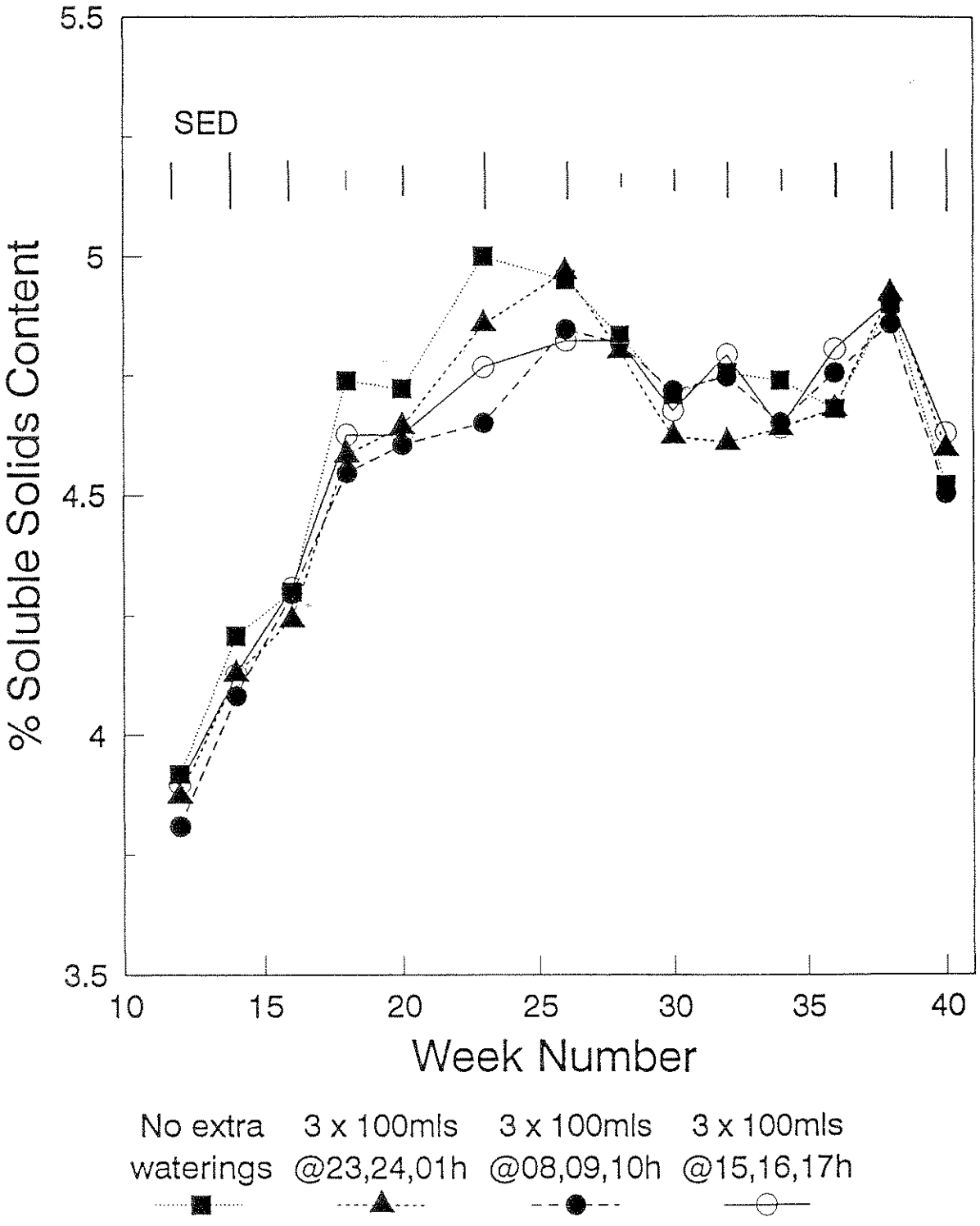


Figure 3.

Effect of irrigation regime on fruit dry matter content

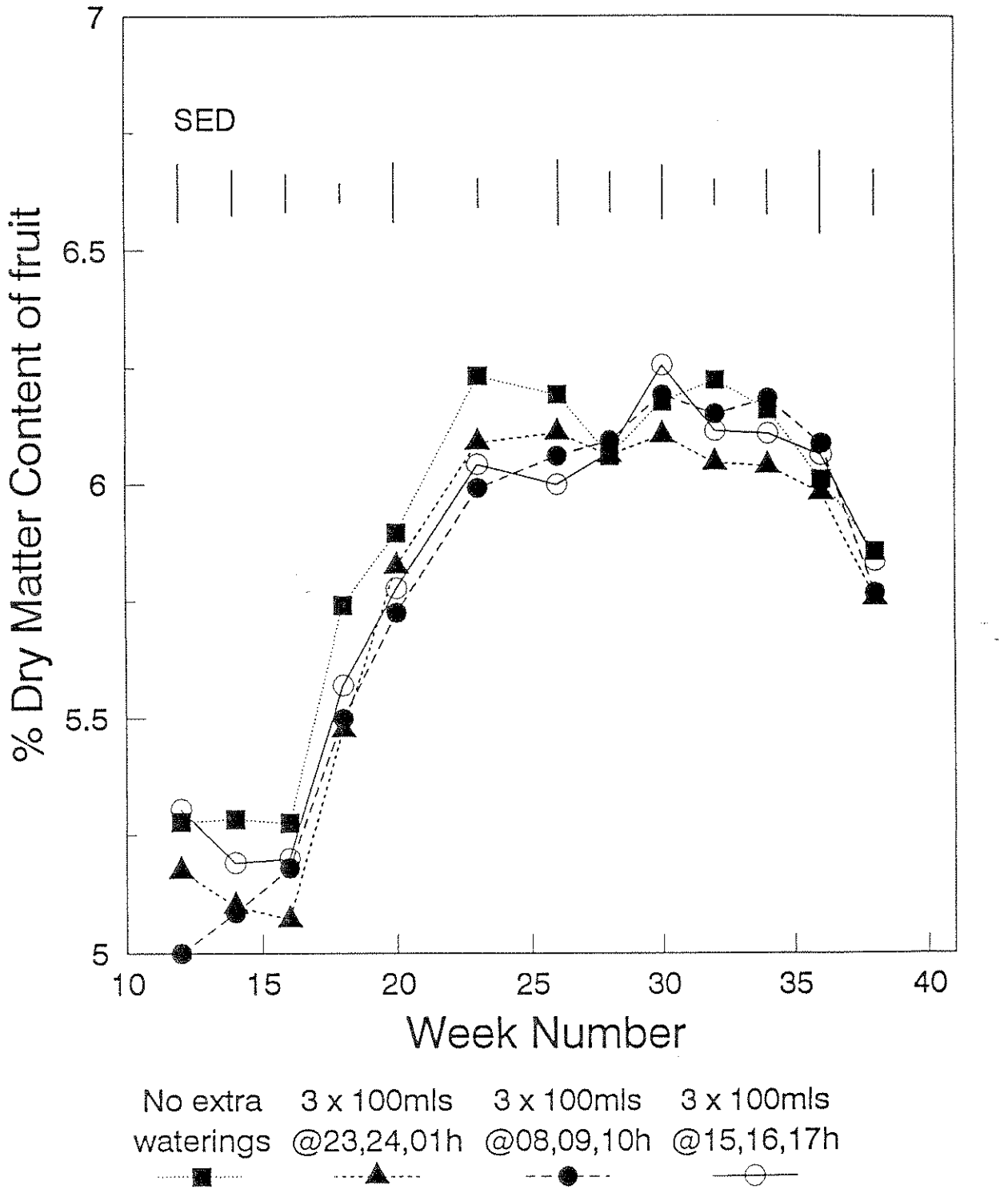


Figure 4.
Effect of irrigation regime on % run-off
(excluding the 3 x 100mls @ 23, 24, 01 h treatment)

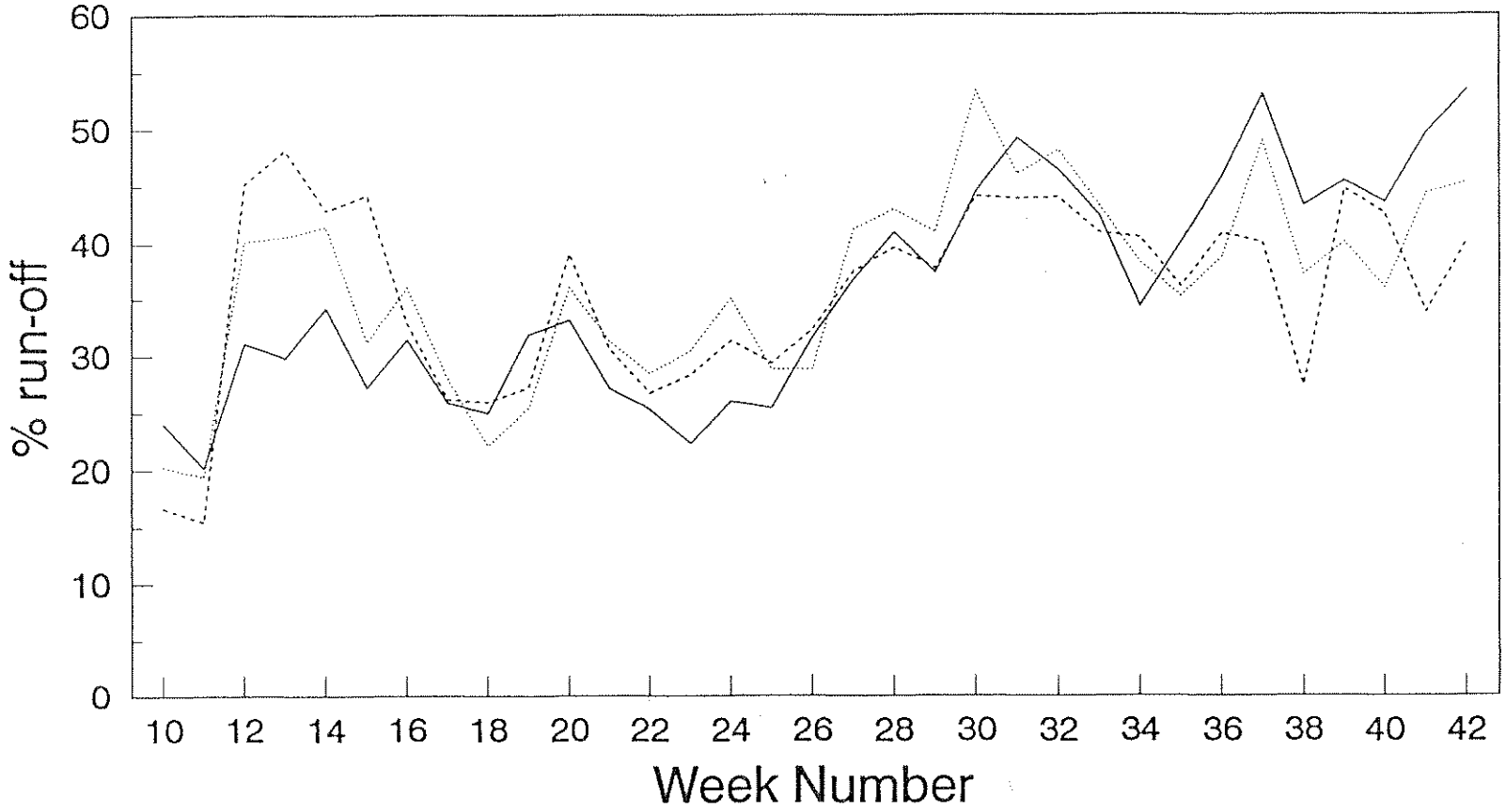


Figure 5.
Effect of Growing regime on % run-off
(excluding data from the 3 x 100mls @ 23, 24, 01 h treatment)

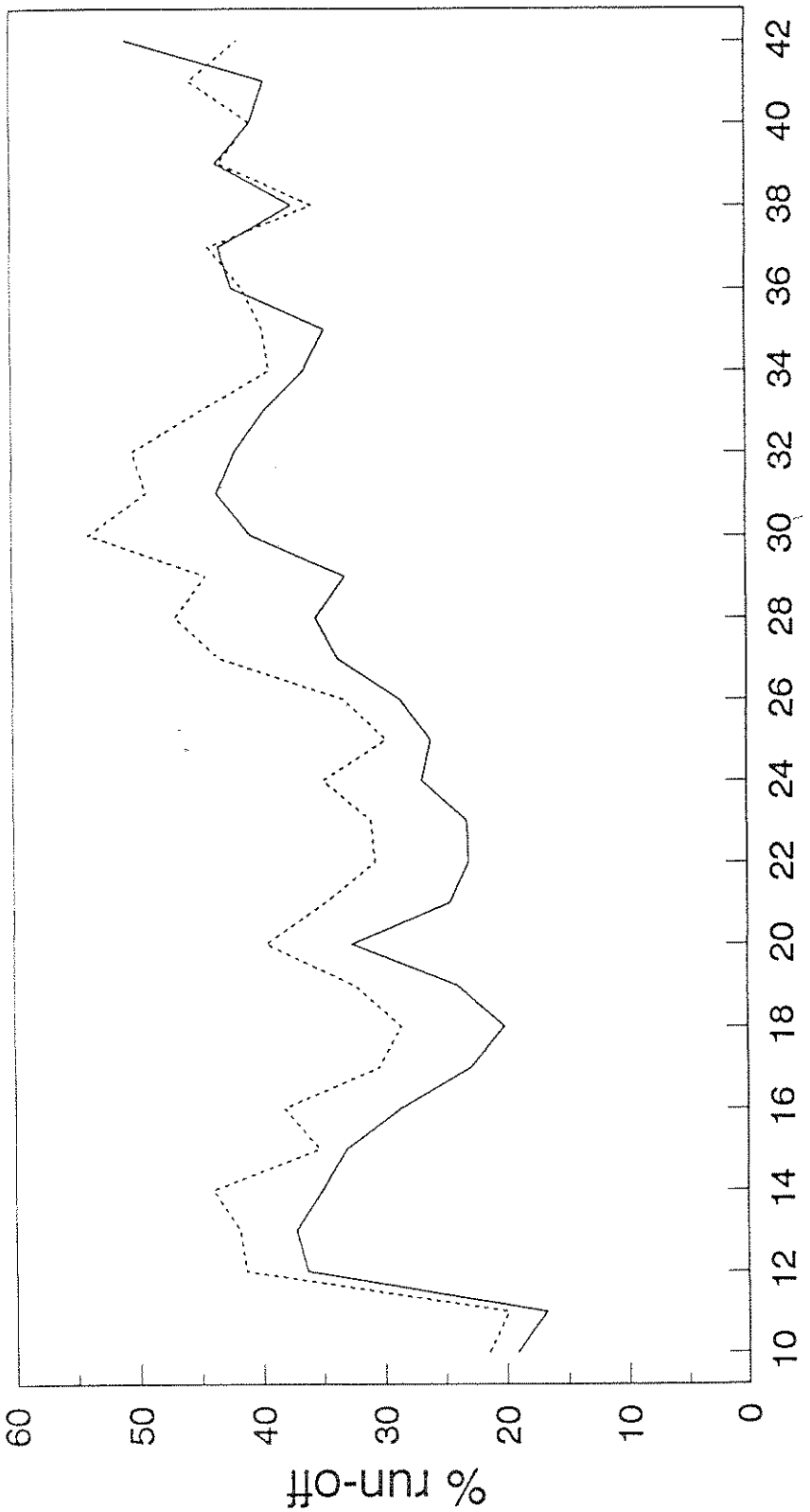


Figure 6.
Effect of Substrate media on % run-off
(excluding 3 x 100mls @ 23, 24, 01 h treatment)

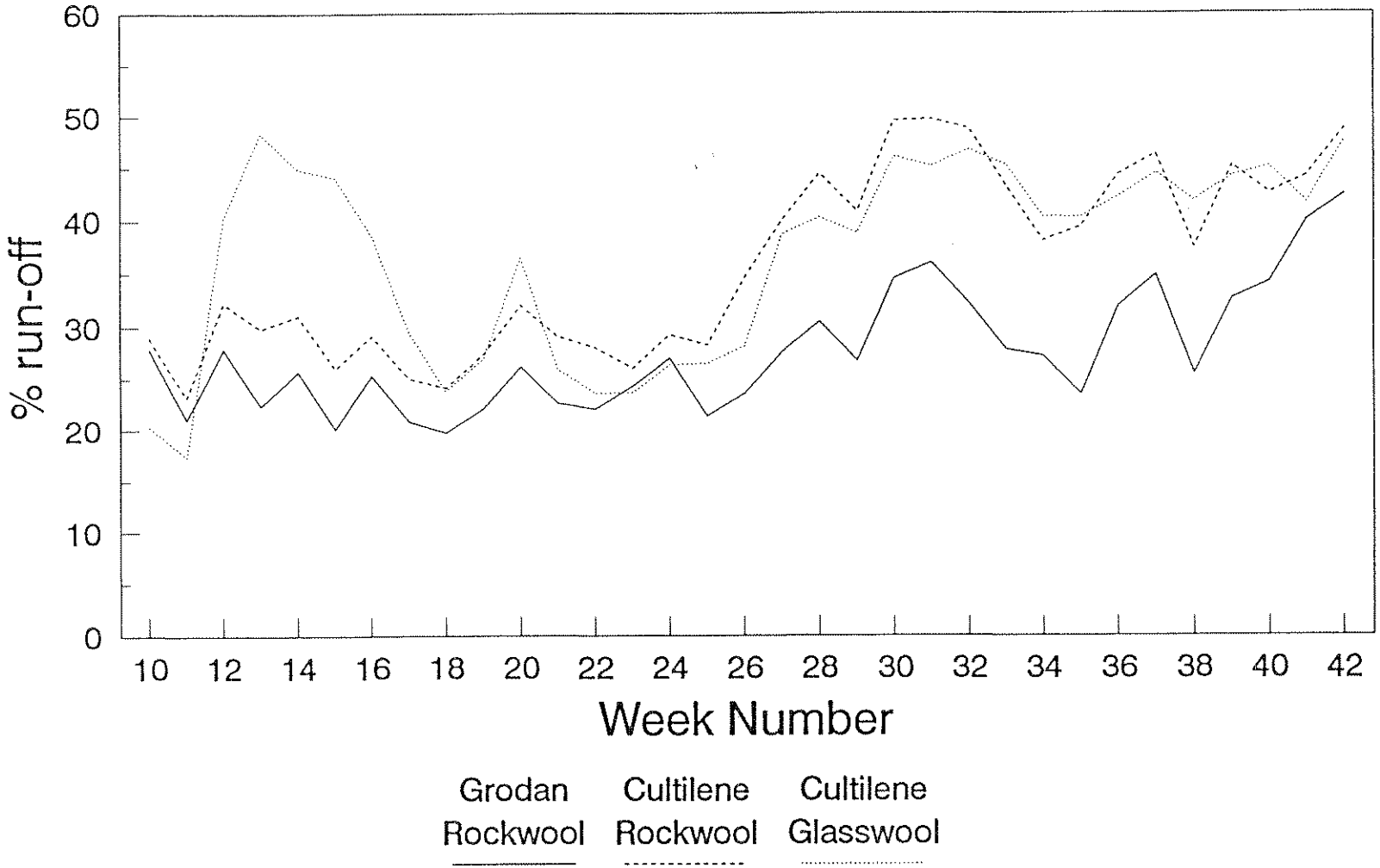
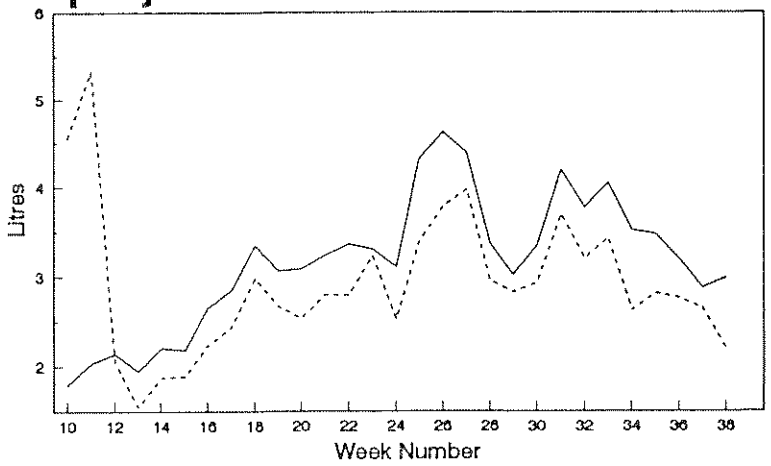
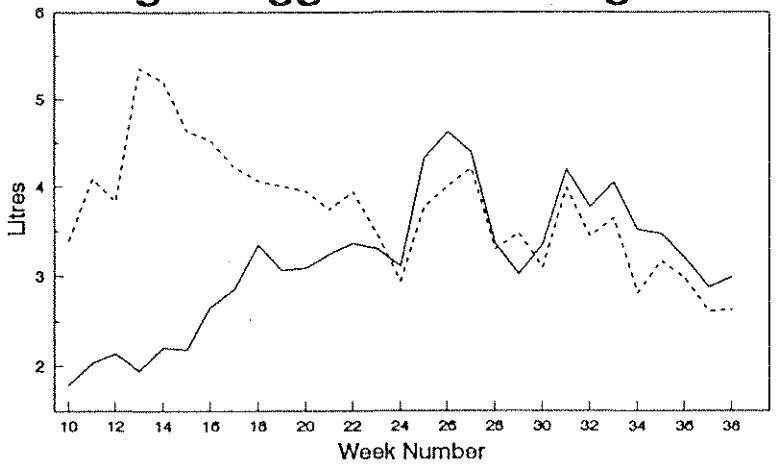
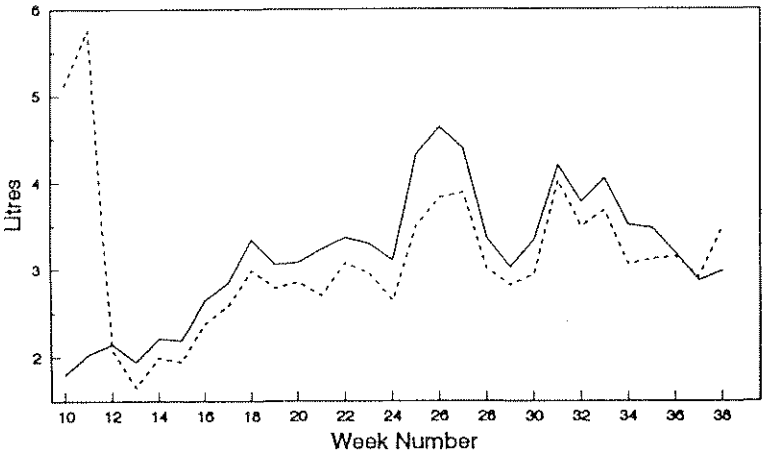


Figure 7.
Effect of irrigation regime on litres applied per plant per day compared to projected litres based on the number of light triggered waterings







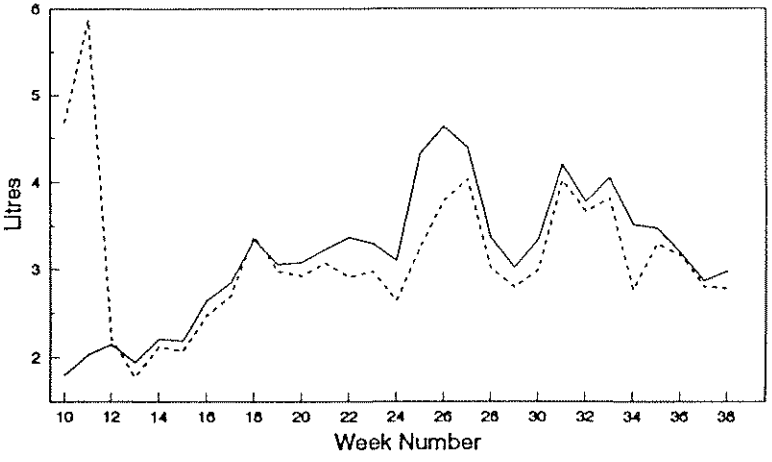


Figure 8.
Conductivities for the 4 irrigation regimes in Grodan slabs on the Double row growing system

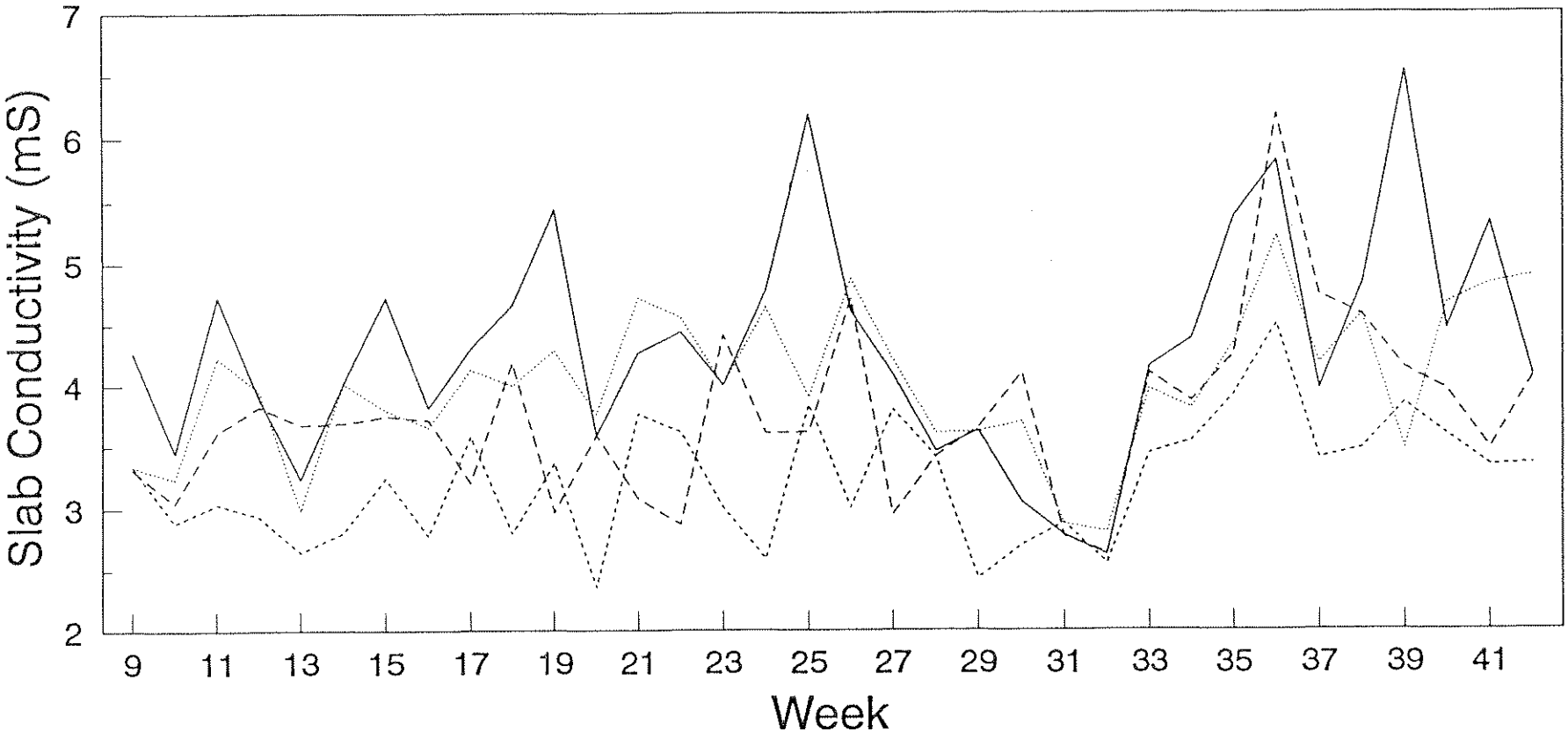
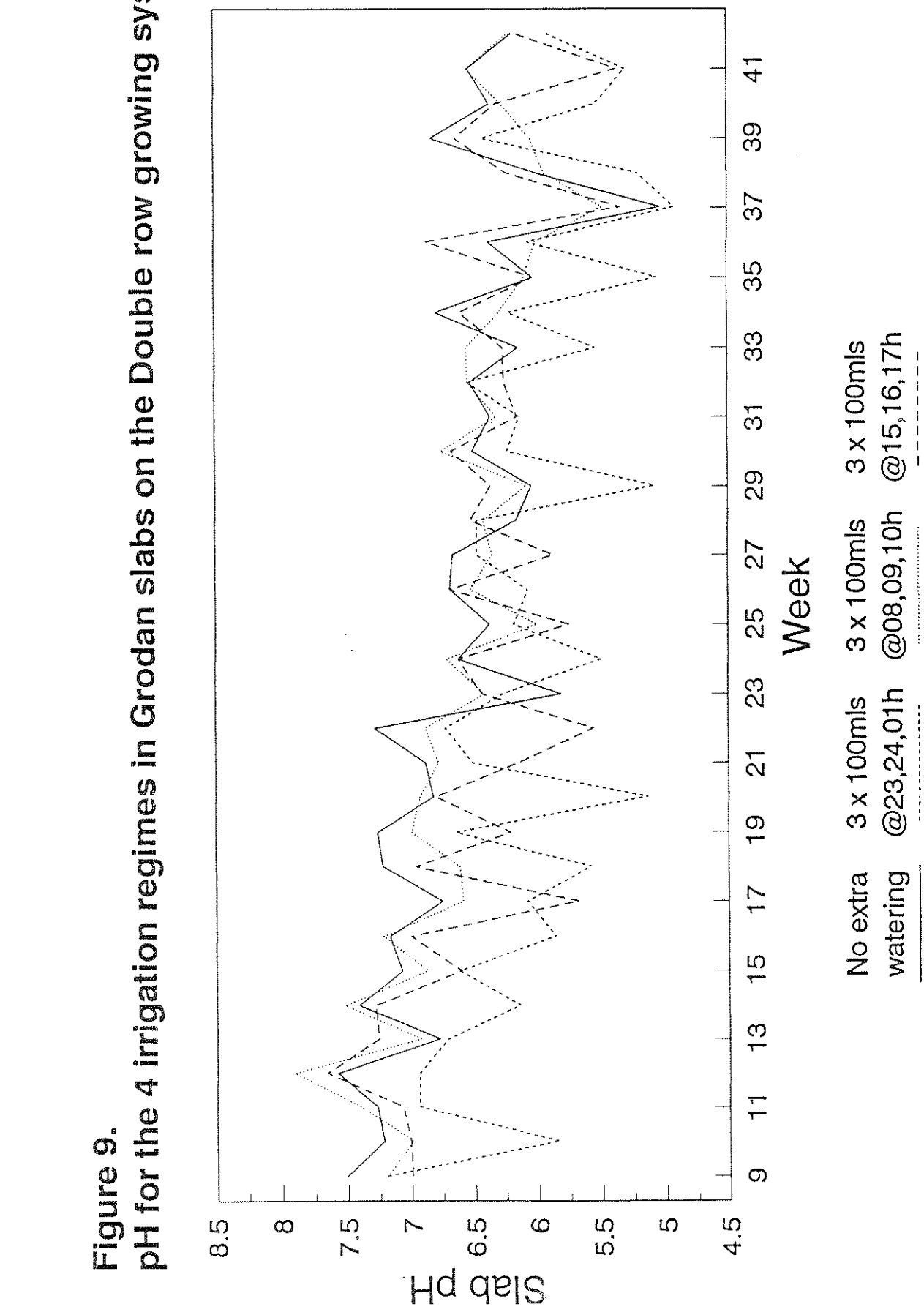


Figure 9.
pH for the 4 irrigation regimes in Grodan slabs on the Double row growing system



DISCUSSION

The 1992/93 irrigation trial, reported here, found no significant differences in yield between 'extra watering treatments' and a 'no extra watering treatment' (control) or between extra waterings applied at different times of day. The highest yielding treatment was the extra water at night treatment but additional yield may have been a result of a minor fault with the irrigation system which allowed slightly higher volumes to be applied than was intended. The lack of any significant differences between the irrigation regimes suggests that the standard 150ml per 100 J cm^{-2} was more than adequate in providing the plants with enough water.

The 1991/92 irrigation trial at Efford revealed higher yields from a night watering sub-treatment across all four of the main irrigation frequency treatments. However, the size of the difference in yield was not consistent across these main treatments (Table 6, page 26). The difference between the no night watering treatment and the night watering treatment was greatest under the least frequent (400ml per application) treatment. It is perhaps not surprising then that under the 1992/93 standard regime of 150ml per application any benefits of night watering were small.

The higher dry matter and soluble solids content of the no extra watering treatment early in the season is coincident with higher slab conductivity. Early in the season the absence of extra waterings would have been significant, however, later, as a greater number of waterings were triggered by light the extra watering became less important and the difference between no extra water and extra water treatments diminished.

In 1991/92 the Double Rows outyielded the V-System by nearly 6% to the end of September. In 1992/93 the difference was only 1.8%, the V-System performing less well at the start of the season. The V-System heads are lower than the Double Row heads until they reach wire height due to the plants having been knocked over. For this reason the Double Row plants are likely to have received better light conditions early in the season. In addition V-System plants would have benefitted more from a lower starting population than was used in this experiment. The increased run-off from the V-System compared to the Double Rows was expected due to the reduced slab volume. The fact that the extra run-off was not coincident with reduced yield in the V-System is further evidence that the crop was receiving more than enough water.

A difference in yield between medias was evident in the first half of the season. The Grodan rockwool outyielded the Cultilene rockwool and glasswool. However, the watering regimes employed in the trial were likely to favour the Grodan rockwool. A regime of more frequent waterings of lower volume might have benefitted the Cultilene substrates.

CONCLUSIONS

1. The application of extra waterings had little impact on yield in this trial where 150ml/100 J cm^{-2} incident radiation were applied to each plant.

2. The extra waterings reduced the soluble solids and dry matter content of fruit early in the season.

3. The timing of applications of extra water had no effect on yield or fruit quality.

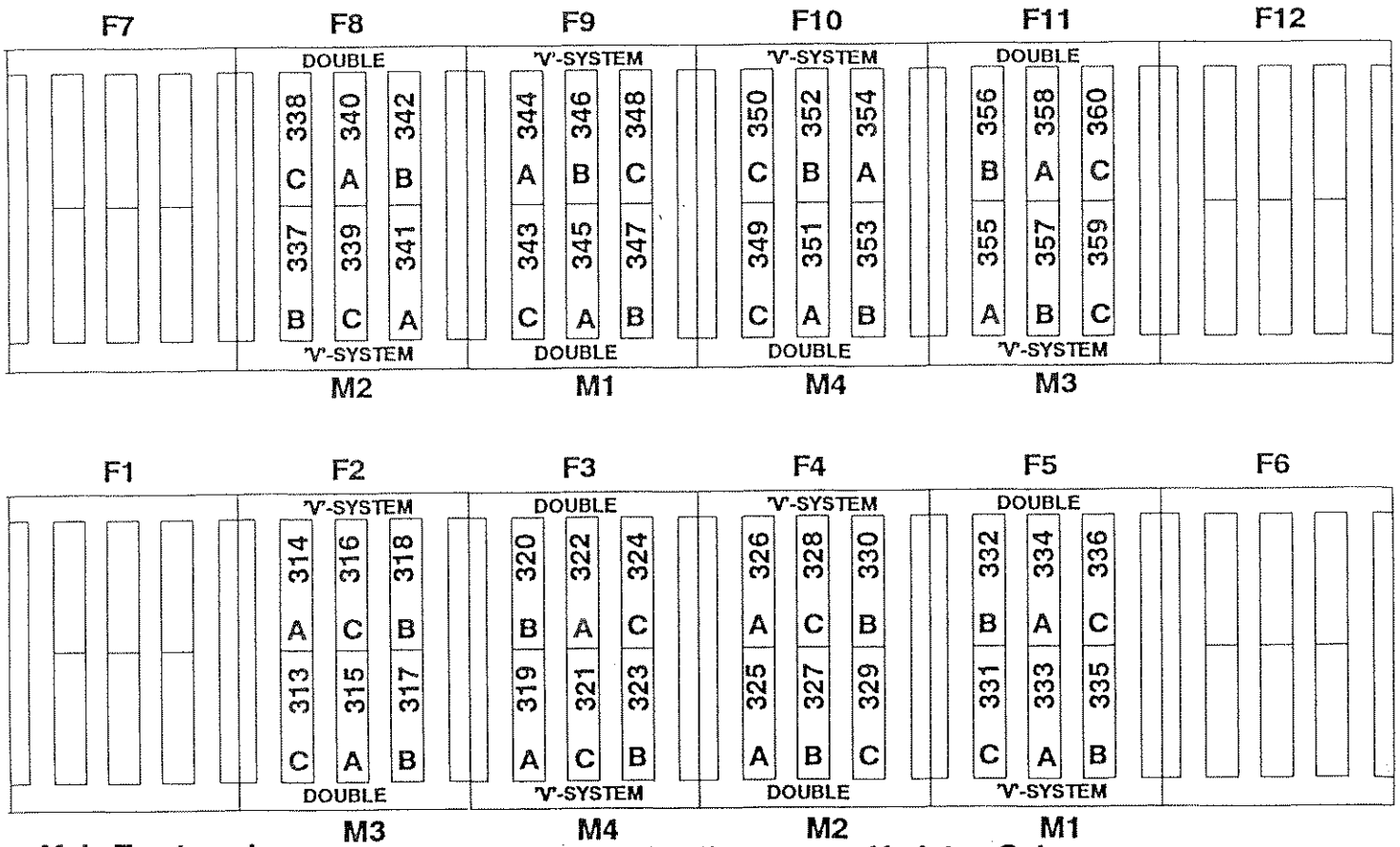
4. The V-System performed as well as the Double Rows, except very early in the season. Higher percentage run-off was recorded for the V-System.

5. There were marked differences in percentage run-off and slight differences in yield between substrates under the irrigation regimes imposed.

Table 6 **The effect of extra water at night on total yield (kgm^{-2}) in the 1991/92 irrigation trial for the four irrigation frequencies.**

Volume per application (same volume/day)	No extra water	Extra Water at night
50ml	47.48	49.40
100ml	48.99	49.23
200ml	47.45	52.12
400ml	44.70	51.79

HDC IRRIGATION TRIAL 1992/1993
PLAN OF TREATMENTS (F-BLOCK)



Main Treatments
M1 - No extra waterings
M2 - 3 x 100ml extra @ 23, 24 & 01hrs
M3 - 3 x 100ml extra @ 08, 09 & 10hrs
M4 - 3 x 100ml extra @ 15, 16 & 17hrs

Media
A - Grodan
B - Cultilene
C - Glasswool

Variety - Calypso
Plant Spacing - 476mm
20 plants/plot Plot area = 7.61m²
Initial population 2.62 plants/m² or 10,600/acre

Appendix 1.

APPENDIX II

Crop Diary

Seed Sown	3.11.92
Plants moved to final position	10.12.92
Slab contact	7.01.93
Treatments commenced	14.02.93
First fruit picked	24.02.93
Sideshoots taken on 1 in 4 plants	11.03.93
Stopped heads	10.09.93
Final recorded pick and end of trial	28.10.93

Pest and Disease Control

A number of beneficial insects were introduced to combat the following pests:-

Predator	Pest
Encarsia formosa	whitefly
Dacnusa/Diglyphus	leaf miner
Aphidius	aphids
Anagrus atomus	leafhopper

Insecticide applications

Product	Date	Target
Torque (Fenbutatin oxide)	19.06.93	red spider mite
Savona (Fatty acids)	01.07.93	whitefly
Torque (Fenbutatin oxide)	06.07.93	red spider mite
Savona (Fatty acids)	14.07.93	whitefly
Torque (Fenbutatin oxide)	16.07.93	red spider mite
Savona (Fatty acids)	20.07.93	whitefly
Savona (Fatty acids)	29.07.93	whitefly
Torque (Fenbutatin oxide)	09.08.93	red spider mite
Torque (Fenbutatin oxide)	27.08.93	red spider mite
Childion (Dicofel & tetradifon)	08.10.93	red spider mite
Hostaquick (Heptenophos)	22.10.93	leafhopper
Childion (Dicofel & tetradifon)	29.10.93	red spider mite

Fungicide applications

Product	Date	Target
Rubigan (fenarimol)	07.03.93	Powdery mildew
Elvaron (dichlofluanid)	12.03.93	Botrytis
Thiovit (sulphur)	26.03.93	Powdery mildew
Bravo (chlorothalonil)	03.04.93	Botrytis
Rovral (iprodione)	16.04.93	Botrytis
Bravo (chlorothalonil)	01.05.93	Botrytis
Bravo (chlorothalonil)	15.05.93	Botrytis
Elvaron (dichlofluanid)	28.05.93	Botrytis
Bravo (chlorothalonil)	23.07.93	Botrytis
Bravo (chlorothalonil)	05.08.93	Botrytis
Rovral (iprodione)	20.08.93	Botrytis
Rovral (iprodione)	17.09.93	Botrytis

APPENDIX III

Effect of irrigation regimes on the date of first anthesis and first pick on trusses 1 - 10.

Irrigation regime	Day number of first anthesis Truss 1	2	3	4	5	6	7	8	9	10
No extra waterings	364	10	19	27	39	47	55	63	69	76
3 x 100mls @ 23, 24, 01 h	367	12	21	30	40	48	55	63	69	76
3 x 100mls @ 98, 09, 10 h	367	12	20	30	40	48	55	63	70	76
3 x 100mls @ 15, 16, 17 h	366	12	20	29	40	48	55	62	69	75
SED (3 d.f)	*0.693*	*0.837*	*0.816*	*1.434*	*1.091*	*0.795*	*0.655*	*0.444*	*0.628*	*0.475*
LSD (5%)	*1.631*	*1.969*	*1.920*	*3.374*	*2.567*	*1.871*	*1.541*	*1.045*	*1.478*	*1.118*
Significance	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*

Irrigation regime	Day number of first pick Truss 1	2	3	4	5	6	7	8	9	10
No extra waterings	64	77	85	92	100	106	113	120	126	131
3 x 100mls @ 23, 24, 01 h	68	79	86	93	101	107	114	120	126	131
3 x 100mls @ 98, 09, 10 h	68	78	86	94	101	107	114	120	127	133
3 x 100mls @ 15, 16, 17 h	67	78	87	93	100	106	113	120	126	132
SED (3 d.f)	*0.947*	*1.559*	*0.666*	*0.697*	*0.571*	*0.767*	*0.478*	*0.205*	*0.834*	*0.506*
LSD (5%)	*2.228*	*3.668*	*1.567*	*1.640*	*1.343*	*1.805*	*1.125*	*0.482*	*1.962*	*1.191*
Significance	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*

APPENDIX IV

Effect of irrigation regimes growing system and substrate on total yield (kgm^{-2})

Irrigation regime	Growing system	Substrate	Mar	Apr	May	Jun	Jul	Aug	Sep	to end Sep
No extra waterings	Double Row	Grodan rockwool	3.05	6.00	8.48	8.75	8.76	7.76	6.79	49.58
No extra waterings	Double Row	Cultilene rockwool	2.54	5.83	8.28	9.09	8.85	7.89	6.74	49.22
No extra waterings	Double Row	Cultilene glasswool	2.60	5.57	8.21	8.99	8.49	7.60	6.66	48.12
No extra waterings	V-System	Grodan rockwool	2.29	5.76	8.90	9.52	9.16	7.94	6.76	50.32
No extra waterings	V-System	Cultilene rockwool	2.06	5.41	9.12	9.32	8.96	7.22	6.64	48.73
No extra waterings	V-System	Cultilene glasswool	2.11	5.44	8.25	8.73	8.84	7.62	6.62	47.61
3x100mls @ 23,24,01h	Double Row	Grodan rockwool	2.62	5.99	9.34	9.98	9.57	8.03	6.82	52.34
3x100mls @ 23,24,01h	Double Row	Cultilene rockwool	2.51	5.94	9.09	9.55	9.22	7.87	7.15	51.33
3x100mls @23,24,01h	Double Row	Cultilene glasswool	2.28	5.81	9.49	9.89	9.44	7.54	6.93	51.38
3x100mls @ 23,24,01h	V-System	Grodan rockwool	2.42	5.83	9.27	9.22	9.28	7.89	6.79	50.68
3x100mls @ 23,24,01h	V-System	Cultilene rockwool	2.18	5.85	8.35	8.98	8.87	7.36	6.94	48.52
3x100mls @ 23,24,01h	V-System	Cultilene glasswool	2.32	5.47	9.23	9.07	8.83	7.37	6.43	48.72
3x100mls @ 08,09,10h	Double Row	Grodan rockwool	2.67	6.04	8.40	8.62	9.18	7.65	7.40	49.95
3x100mls @ 08,09,10h	Double Row	Cultilene rockwool	2.24	5.80	8.45	9.30	9.66	8.24	7.54	51.22
3x100mls @ 08,09,10h	Double Row	Cultilene glasswool	2.49	5.68	8.29	8.59	9.34	7.71	7.31	49.40
3x100mls @ 08,09,10h	V-System	Grodan rockwool	2.31	5.74	9.25	9.28	9.62	8.09	7.37	51.66
3x100mls @ 08,09,10h	V-System	Cultilene rockwool	2.12	5.59	8.21	9.00	9.22	7.71	6.55	48.40
3x100mls @ 08,09,10h	V-System	Cultilene glasswool	2.10	5.55	8.62	9.12	8.88	7.70	6.70	48.67
3x100mls @ 15,16,17h	Double Row	Grodan rockwool	2.70	5.82	8.32	8.57	9.15	7.33	6.40	48.29
3x100mls @ 15,16,17h	Double Row	Cultilene rockwool	2.65	6.35	8.68	8.97	8.85	7.21	6.85	49.55
3x100mls @ 15,16,17h	Double Row	Cultilene glasswool	2.57	5.65	7.82	8.32	8.43	7.30	6.48	46.56
3x100mls @15,16,17h	V-System	Grodan rockwool	2.23	5.46	8.81	8.78	9.31	7.52	6.81	48.92
3x100mls @ 15,16,17h	V-System	Cultilene rockwool	2.01	5.18	8.86	8.56	8.70	7.53	6.24	47.08
3x100mls @ 15,16,17h	V-System	Cultilene glasswool	2.11	5.27	8.80	8.79	8.97	7.20	6.15	47.28

APPENDIX V

Effect of irrigation regimes growing system and substrate on marketable yield (kg/m^{-2})

Irrigation regime	Growing system	Substrate	Mar	Apr	May	Jun	Jul	Aug	Sep	to end Sep
No extra waterings	Double Row	Grodan rockwool	3.00	5.77	8.35	8.56	8.57	7.26	6.56	48.07
No extra waterings	Double Row	Cultilene rockwool	2.50	5.60	8.17	8.87	8.64	7.22	6.49	47.49
No extra waterings	Double Row	Cultilene glasswool	2.55	5.37	8.08	8.78	8.35	7.09	6.37	46.59
No extra waterings	V-System	Grodan rockwool	2.24	5.53	8.80	9.31	8.94	7.33	6.55	48.70
No extra waterings	V-System	Cultilene rockwool	2.01	5.21	8.97	9.13	8.77	6.70	6.41	47.20
No extra waterings	V-System	Cultilene glasswool	2.09	5.21	8.15	8.54	8.68	7.03	6.38	46.08
3x100mls @ 23,24,01h	Double Row	Grodan rockwool	2.57	5.78	9.16	9.71	9.37	7.49	6.63	50.71
3x100mls @ 23,24,01h	Double Row	Cultilene rockwool	2.46	5.71	8.98	9.36	9.02	7.36	7.01	49.91
3x100mls @23,24,01h	Double Row	Cultilene glasswool	2.24	5.56	9.36	9.67	9.26	6.87	6.68	49.64
3x100mls @ 23,24,01h	V-System	Grodan rockwool	2.36	5.68	9.17	9.04	9.07	7.28	6.62	49.23
3x100mls @ 23,24,01h	V-System	Cultilene rockwool	2.08	5.60	8.19	8.75	8.70	6.74	6.73	46.80
3x100mls @ 23,24,01h	V-System	Cultilene glasswool	2.25	5.29	9.13	8.92	8.62	6.73	6.26	47.21
3x100mls @ 08,09,10h	Double Row	Grodan rockwool	2.64	5.87	8.26	8.41	9.02	7.28	7.17	48.65
3x100mls @ 08,09,10h	Double Row	Cultilene rockwool	2.20	5.60	8.33	9.15	9.50	7.81	7.30	49.89
3x100mls @ 08,09,10h	Double Row	Cultilene glasswool	2.46	5.50	8.16	8.42	9.19	7.35	7.06	48.15
3x100mls @ 08,09,10h	V-System	Grodan rockwool	2.23	5.54	9.14	9.09	9.45	7.75	7.11	50.30
3x100mls @ 08,09,10h	V-System	Cultilene rockwool	2.08	5.32	8.06	8.77	9.05	7.38	6.27	46.93
3x100mls @ 08,09,10h	V-System	Cultilene glasswool	2.03	5.34	8.49	8.94	8.76	7.42	6.50	47.46
3x100mls @ 15,16,17h	Double Row	Grodan rockwool	2.64	5.63	8.22	8.39	9.00	6.98	6.13	46.99
3x100mls @ 15,16,17h	Double Row	Cultilene rockwool	2.61	6.16	8.53	8.74	8.70	6.61	6.61	47.95
3x100mls @ 15,16,17h	Double Row	Cultilene glasswool	2.50	5.39	7.68	8.15	8.25	6.86	6.26	45.08
3x100mls @15,16,17h	V-System	Grodan rockwool	2.15	5.30	8.71	8.58	9.14	7.03	6.65	47.56
3x100mls @ 15,16,17h	V-System	Cultilene rockwool	1.96	4.97	8.74	8.38	8.52	7.21	5.99	45.76
3x100mls @ 15,16,17h	V-System	Cultilene glasswool	2.08	5.07	8.67	8.62	8.78	6.70	5.77	45.69

APPENDIX VI

Effect of irrigation regime, growing system and substrate on percentage Class I fruit

Irrigation regime	Growing system	Substrate	Mar	Apr	May	Jun	Jul	Aug	Sep	to end Sep
No extra waterings	Double Row	Grodan rockwool	89	90	94	95	92	74	91	90
No extra waterings	Double Row	Cultilene rockwool	88	88	94	93	91	75	90	89
No extra waterings	Double Row	Cultilene glasswool	87	89	94	93	92	76	91	89
No extra waterings	V-System	Grodan rockwool	85	88	95	93	92	75	92	89
No extra waterings	V-System	Cultilene rockwool	87	85	94	94	92	73	92	89
No extra waterings	V-System	Cultilene glasswool	82	88	95	93	92	76	90	89
3x100mls @ 23,24,01h	Double Row	Grodan rockwool	80	88	93	93	93	75	92	89
3x100mls @ 23,24,01h	Double Row	Cultilene rockwool	85	87	95	94	91	78	94	90
3x100mls @23,24,01h	Double Row	Cultilene glasswool	85	86	95	93	92	70	91	88
3x100mls @ 23,24,01h	V-System	Grodan rockwool	77	90	95	94	91	79	92	90
3x100mls @ 23,24,01h	V-System	Cultilene rockwool	81	88	94	93	92	75	92	89
3x100mls @ 23,24,01h	V-System	Cultilene glasswool	82	88	95	95	92	76	91	90
3x100mls @ 08,09,10h	Double Row	Grodan rockwool	87	87	94	93	93	82	91	90
3x100mls @ 08,09,10h	Double Row	Cultilene rockwool	86	88	95	95	93	82	91	91
3x100mls @ 08,09,10h	Double Row	Cultilene glasswool	84	89	95	94	92	82	91	90
3x100mls @ 08,09,10h	V-System	Grodan rockwool	80	87	95	93	91	81	89	89
3x100mls @ 08,09,10h	V-System	Cultilene rockwool	84	85	94	93	93	82	91	90
3x100mls @ 08,09,10h	V-System	Cultilene glasswool	80	88	94	95	93	84	92	91
3x100mls @ 15,16,17h	Double Row	Grodan rockwool	84	87	94	93	93	84	90	90
3x100mls @ 15,16,17h	Double Row	Cultilene rockwool	85	88	94	93	93	74	91	89
3x100mls @ 15,16,17h	Double Row	Cultilene glasswool	83	87	95	93	93	80	92	90
3x100mls @15,16,17h	V-System	Grodan rockwool	75	88	94	93	92	80	93	90
3x100mls @ 15,16,17h	V-System	Cultilene rockwool	83	88	95	94	92	81	91	90
3x100mls @ 15,16,17h	V-System	Cultilene glasswool	83	89	94	94	93	81	88	90

APPENDIX VII

Effect of irrigation regime, growing system and substrate on percentage Class II fruit

Irrigation regime	Growing system	Substrate	Mar	Apr	May	Jun	Jul	Aug	Sep	to end Sep
No extra waterings	Double Row	Grodan rockwool	9	6	4	3	6	19	5	7
No extra waterings	Double Row	Cultilene rockwool	11	9	4	4	6	17	6	8
No extra waterings	Double Row	Cultilene glasswool	11	7	5	4	6	18	5	8
No extra waterings	V-System	Grodan rockwool	13	9	4	5	6	17	5	7
No extra waterings	V-System	Cultilene rockwool	11	11	4	4	6	19	5	8
No extra waterings	V-System	Cultilene glasswool	17	8	4	5	6	16	6	8
3x100mls @ 23,24,01h	Double Row	Grodan rockwool	18	9	5	5	5	18	6	8
3x100mls @ 23,24,01h	Double Row	Cultilene rockwool	13	9	4	4	7	15	4	7
3x100mls @23,24,01h	Double Row	Cultilene glasswool	13	9	4	5	6	20	5	8
3x100mls @ 23,24,01h	V-System	Grodan rockwool	20	7	4	4	7	13	6	7
3x100mls @ 23,24,01h	V-System	Cultilene rockwool	15	8	4	4	6	16	5	7
3x100mls @ 23,24,01h	V-System	Cultilene glasswool	15	8	4	4	6	16	6	7
3x100mls @ 08,09,10h	Double Row	Grodan rockwool	12	10	4	5	6	13	6	7
3x100mls @ 08,09,10h	Double Row	Cultilene rockwool	12	8	4	4	6	13	6	7
3x100mls @ 08,09,10h	Double Row	Cultilene glasswool	15	8	4	4	6	13	6	7
3x100mls @ 08,09,10h	V-System	Grodan rockwool	16	9	4	5	7	15	7	8
3x100mls @ 08,09,10h	V-System	Cultilene rockwool	14	10	4	4	5	14	4	7
3x100mls @ 08,09,10h	V-System	Cultilene glasswool	16	8	4	3	5	13	5	7
3x100mls @ 15,16,17h	Double Row	Grodan rockwool	13	9	5	5	5	12	6	7
3x100mls @ 15,16,17h	Double Row	Cultilene rockwool	13	9	5	4	6	17	5	8
3x100mls @ 15,16,17h	Double Row	Cultilene glasswool	14	8	4	5	5	14	5	7
3x100mls @15,16,17h	V-System	Grodan rockwool	21	10	4	5	6	13	5	8
3x100mls @ 15,16,17h	V-System	Cultilene rockwool	15	8	4	4	6	14	5	8
3x100mls @ 15,16,17h	V-System	Cultilene glasswool	16	8	4	4	5	12	5	7

APPENDIX VIII

Effect of irrigation regime, growing system and substrate on percentage waste fruit

Irrigation regime	Growing system	Substrate	Mar	Apr	May	Jun	Jul	Aug	Sep	to end Sep
No extra waterings	Double Row	Grodan rockwool	2	4	2	2	2	7	3	3
No extra waterings	Double Row	Cultilene rockwool	2	4	1	3	2	9	4	4
No extra waterings	Double Row	Cultilene glasswool	2	4	2	2	2	7	4	3
No extra waterings	V-System	Grodan rockwool	2	4	1	2	3	8	3	3
No extra waterings	V-System	Cultilene rockwool	2	4	2	2	2	7	3	3
No extra waterings	V-System	Cultilene glasswool	1	4	1	2	2	8	4	3
3x100mls @ 23,24,01h	Double Row	Grodan rockwool	2	4	2	3	2	7	3	3
3x100mls @ 23,24,01h	Double Row	Cultilene rockwool	2	4	1	2	2	7	2	3
3x100mls @23,24,01h	Double Row	Cultilene glasswool	2	4	1	2	2	9	4	3
3x100mls @ 23,24,01h	V-System	Grodan rockwool	3	3	1	2	2	8	2	3
3x100mls @ 23,24,01h	V-System	Cultilene rockwool	5	4	2	3	2	9	3	4
3x100mls @ 23,24,01h	V-System	Cultilene glasswool	3	2	1	2	2	9	3	3
3x100mls @ 08,09,10h	Double Row	Grodan rockwool	1	3	2	2	2	5	3	3
3x100mls @ 08,09,10h	Double Row	Cultilene rockwool	1	4	1	2	2	5	3	3
3x100mls @ 08,09,10h	Double Row	Cultilene glasswool	1	3	2	2	2	5	3	3
3x100mls @ 08,09,10h	V-System	Grodan rockwool	3	4	1	2	2	4	4	3
3x100mls @ 08,09,10h	V-System	Cultilene rockwool	3	5	2	3	2	4	4	3
3x100mls @ 08,09,10h	V-System	Cultilene glasswool	4	4	2	2	1	4	3	2
3x100mls @ 15,16,17h	Double Row	Grodan rockwool	2	3	1	2	2	5	4	3
3x100mls @ 15,16,17h	Double Row	Cultilene rockwool	2	3	2	3	2	8	4	3
3x100mls @ 15,16,17h	Double Row	Cultilene glasswool	3	5	2	2	2	6	3	3
3x100mls @15,16,17h	V-System	Grodan rockwool	4	3	1	2	2	7	2	3
3x100mls @ 15,16,17h	V-System	Cultilene rockwool	3	4	1	2	2	4	4	3
3x100mls @ 15,16,17h	V-System	Cultilene glasswool	2	4	1	2	2	7	6	3

APPENDIX IX

Effect of irrigation regime, growing system and substrate on percentage of Class I fruit in grade C (>57mm)

Irrigation regime	Growing system	Substrate	Mar	Apr	May	Jun	Jul	Aug	Sep	to end Sep
No extra waterings	Double Row	Grodan rockwool	3	3	17	20	17	19	13	15
No extra waterings	Double Row	Cultilene rockwool	2	2	20	21	15	18	16	15
No extra waterings	Double Row	Cultilene glasswool	3	4	19	23	17	22	18	17
No extra waterings	V-System	Grodan rockwool	2	10	28	26	19	19	18	20
No extra waterings	V-System	Cultilene rockwool	2	10	29	26	22	21	22	22
No extra waterings	V-System	Cultilene glasswool	1	6	23	22	18	21	16	18
3x100mls @ 23,24,01h	Double Row	Grodan rockwool	0	7	29	26	18	20	13	19
3x100mls @ 23,24,01h	Double Row	Cultilene rockwool	1	8	25	24	16	18	12	17
3x100mls @23,24,01h	Double Row	Cultilene glasswool	1	8	31	30	23	19	16	22
3x100mls @ 23,24,01h	V-System	Grodan rockwool	2	6	21	21	16	17	8	15
3x100mls @ 23,24,01h	V-System	Cultilene rockwool	0	6	16	19	15	17	16	15
3x100mls @ 23,24,01h	V-System	Cultilene glasswool	4	12	23	23	17	19	14	18
3x100mls @ 08,09,10h	Double Row	Grodan rockwool	2	7	22	25	18	17	19	18
3x100mls @ 08,09,10h	Double Row	Cultilene rockwool	2	7	23	20	20	20	21	19
3x100mls @ 08,09,10h	Double Row	Cultilene glasswool	1	6	21	20	17	21	20	18
3x100mls @ 08,09,10h	V-System	Grodan rockwool	1	6	26	19	15	18	18	17
3x100mls @ 08,09,10h	V-System	Cultilene rockwool	0	7	25	19	16	16	14	16
3x100mls @ 08,09,10h	V-System	Cultilene glasswool	5	6	24	19	16	12	11	15
3x100mls @ 15,16,17h	Double Row	Grodan rockwool	1	4	18	22	14	20	14	15
3x100mls @ 15,16,17h	Double Row	Cultilene rockwool	3	9	22	23	18	23	18	18
3x100mls @ 15,16,17h	Double Row	Cultilene glasswool	0	3	16	21	14	21	10	14
3x100mls @15,16,17h	V-System	Grodan rockwool	2	9	24	26	20	23	18	20
3x100mls @ 15,16,17h	V-System	Cultilene rockwool	1	9	23	27	17	20	9	18
3x100mls @ 15,16,17h	V-System	Cultilene glasswool	1	8	23	22	17	15	11	17

APPENDIX X

Effect of irrigation regime, growing system and substrate on percentage of Class I fruit in grade D (47-57mm)

Irrigation regime	Growing system	Substrate	Mar	Apr	May	Jun	Jul	Aug	Sep	to end Sep
No extra waterings	Double Row	Grodan rockwool	83	81	74	71	75	74	76	75
No extra waterings	Double Row	Cultilene rockwool	79	84	73	70	77	74	72	75
No extra waterings	Double Row	Cultilene glasswool	80	80	73	68	74	70	73	73
No extra waterings	V-System	Grodan rockwool	79	78	66	65	74	75	71	71
No extra waterings	V-System	Cultilene rockwool	76	76	65	67	72	72	68	70
No extra waterings	V-System	Cultilene glasswool	75	79	70	68	74	73	71	72
3x100mls @ 23,24,01h	Double Row	Grodan rockwool	88	82	65	66	74	70	74	72
3x100mls @ 23,24,01h	Double Row	Cultilene rockwool	81	80	69	68	75	72	75	73
3x100mls @23,24,01h	Double Row	Cultilene glasswool	82	80	62	63	71	72	72	69
3x100mls @ 23,24,01h	V-System	Grodan rockwool	79	81	72	70	74	73	75	74
3x100mls @ 23,24,01h	V-System	Cultilene rockwool	81	82	76	71	76	74	72	75
3x100mls @ 23,24,01h	V-System	Cultilene glasswool	75	74	71	69	73	71	73	72
3x100mls @ 08,09,10h	Double Row	Grodan rockwool	84	82	70	65	74	75	72	73
3x100mls @ 08,09,10h	Double Row	Cultilene rockwool	74	79	69	70	72	73	68	72
3x100mls @ 08,09,10h	Double Row	Cultilene glasswool	80	78	69	69	76	71	71	72
3x100mls @ 08,09,10h	V-System	Grodan rockwool	81	82	67	70	78	75	69	73
3x100mls @ 08,09,10h	V-System	Cultilene rockwool	75	79	67	70	76	76	75	74
3x100mls @ 08,09,10h	V-System	Cultilene glasswool	77	80	68	71	77	77	78	75
3x100mls @ 15,16,17h	Double Row	Grodan rockwool	83	82	74	69	78	72	71	75
3x100mls @ 15,16,17h	Double Row	Cultilene rockwool	84	79	71	68	74	71	71	72
3x100mls @ 15,16,17h	Double Row	Cultilene glasswool	83	81	74	69	77	72	74	74
3x100mls @15,16,17h	V-System	Grodan rockwool	83	77	70	67	72	70	68	71
3x100mls @ 15,16,17h	V-System	Cultilene rockwool	69	78	69	65	73	73	75	71
3x100mls @ 15,16,17h	V-System	Cultilene glasswool	75	79	69	70	74	76	75	73

HORTICULTURE RESEARCH INTERNATIONAL

EFFORD

Report to:

Horticultural Development Council
18 Lavant Street
PETERSFIELD
Hampshire GU32 3EW

Tel: 0730 263736
Fax: 0730 265394

HRI Contract Manager:

Miss M A Scott
HRI Efford
LYMINGTON
Hampshire SO41 0LZ

Tel: 0590 673341
Fax: 0590 671553

Period of Investigation: November 1992 - October 1993
Date of issue of report: April 1994
No. of pages in report: Forty Three
No. of copies of report: Six
This is copy no. 3: Issued to Horticultural Development Council

FINAL CONTRACT REPORT

Tomatoes: Irrigation Regimes for a Long Season Rockwool Crop 1992/93

HDC PC82

PRINCIPAL WORKERS

HRI EFFORD

Dr D J Hand BSc (Hons), PhD, M.I. Hort	Technical Officer
Mr M Fussell BSc (Hons) (Author of report)	Scientific Officer
Mrs S Foster	Scientific Officer
Miss J Basham	Assistant Scientific Officer
Mr M Wainwright, BSc	Assistant Scientific Officer
Mr C Vigor	Nursery Staff
Mr M Verran	Nursery Staff
Mr S Stagg	Nursery Staff
Mr M Reay	Computer Systems, Maintenance

HRI LITTLEHAMPTON

Mr R H Edmondson MSc	Statistician

AUTHENTIFICATION

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

Signature ..... Margaret Scott
Deputy Head of Station

Date ..29/4/94.....

Report Authorised by .....
Signature

M R Shipway
Head of Station

HRI Efford
LYMINGTON
Hants
SO41 0LZ

Date 29/4/94.....

CONTENTS

	Page
Acknowledgements	1
Relevance to Growers and Practical Application	2
Experimental Section	3
Summary	3
Introduction	4
Objectives	4
Materials and Methods	5
Site Details	5
Treatments	5
Cultural Techniques	6
Assessments	7
Fruit Quality Assessment Methods	7
Disorder Assessments	7
Shelf-life Assessments and Chemical Analysis	8
Experimental Design and Explanation of Statistical Terms	8
Results	10
Plant Growth and Development	10
Yield and Gradeout	10
Fruit Quality	10
Levels of Physical Disorders	10
Shelf-life	11
Internal Composition	11
Run-off Percentages	11
Applied Volumes and Slab Environment	11
Discussion	24
Conclusions	25

Appendices

		Page
Appendix I:	Trial Plan	27
Appendix II:	Crop Diary	28
Appendix III:	Effect of irrigation regimes on the date of first anthesis and first pick on trusses 1-10	30
Appendix IV:	Effect of irrigation regimes, and substrate on Total Yield	31
Appendix V:	Effect of irrigation regime, growing system and substrate on Marketable Yield	32
Appendix VI:	Effect of irrigation regime, growing system and substrate on Percentage Class I fruit	33
Appendix VII:	Effect of irrigation regime, growing system and substrate on Percentage Class II fruit	34
Appendix VIII:	Effect of irrigation regime, growing system and substrate on Percentage waste fruit	35
Appendix IX:	Effect of irrigation regime, growing system and substrate on Percentage Class I fruit in grade C	36
Appendix X:	Effect of irrigation regime, growing system and substrate on Percentage Class I fruit in grade D	37
Appendix XI:	Effect of irrigation regime, growing system and substrate on Percentage Class I fruit in grade E	38
Appendix XII:	Effect of irrigation regimes on levels of Gold Spot	39
Appendix XIII:	Effect of irrigation regimes on the Percentage soluble solids content of fruit	40
Appendix XIV:	Effect of irrigation regimes on the Percentage Dry Matter content of fruit.	41
Appendix XV:	Contract Terms and Conditions	42

ANNUAL REPORT APRIL 1994
HDC PC82

TOMATOES: IRRIGATION REGIMES FOR A LONG SEASON ROCKWOOL CROP

Dr D J Hand
M Fussell

HRI Efford

Co-ordinator: Mr G Hayman

Commenced: November 1992

Completed: October 1993

Key Words: Tomato, Irrigation regimes, Rockwool

ACKNOWLEDGEMENTS

The assistance of HDC Co-ordinator Mr Gerry Hayman with the planning of this trial is gratefully acknowledged. Dr Nigel Dungey also provided valuable advice.

RELEVANCE TO GROWERS AND PRACTICAL APPLICATION

The principal aim of this study was to investigate whether extra irrigation rounds applied either early in the morning (0800, 0900 and 1000h), late afternoon (1500, 1600 and 1700h) or around midnight (2300, 2400 and 0100h) resulted in increased yield as was the case in 1991/92 (PC23c) when additional irrigation rounds were applied around midnight. In the case of the latter experiment it was unclear whether the yield increase was a function of the time of application or merely a response to the increased total volume.

The trial reported here clearly demonstrated, however, that additional waterings imposed on a standard irrigation regime of 150ml per plant/100Jcm^2 had no significant yield benefit. The 'night' watering treatment produced a final yield of 50.50kgm^{-2} compared with 48.93kgm^{-2} produced by the 'control' where no extra waterings were applied.

Extra water had the effect of reducing soluble solids and dry matter content of fruit early in the season and reducing levels of Gold Spot.

The trial also sought to investigate whether different growing systems and medias behaved differently under the different irrigation regimes. Since the irrigation regimes had little effect overall, it was not surprising that all sub-treatments behaved similarly. While it was not the intention of the trial to compare growing systems and medias directly some interesting results were obtained.

The V-System performed as well as the Double Rows for most of the season, demonstrating that reduced root volume does not result in reduced yield so long as plants are provided with sufficient nutrients and water. Higher run-off percentages were recorded for the V-System.

Small differences in yield were found between substrates. The most water retentive, Grodan rockwool, resulted in slightly higher yield than the less water retentive Cultilene rockwool and glasswool. Higher run-off percentages were associated with the Cultilene crops suggesting that a more frequent irrigation regime with smaller volumes per application might have suited them better. However, it is not suggested that the irrigation regimes evaluated here were in any way 'optimal' for the substrates included in the study.

EXPERIMENTAL SECTION

SUMMARY

Work done at Efford during the 1992/93 cropping season investigated the effects of extra waterings and their timing on the yield and fruit quality of a long season tomato crop *(Lycopersicon esculentum Mill)*. Two growing systems and three substrates were included as sub-treatments to determine any differences in behaviour to the irrigation regimes.

A crop of Calypso was sown on 3 November 1992. Propagation and subsequent early growth were standard throughout and followed current commercial practice. Irrigation regimes commenced on 14 February. Three extra waterings of 100 ml per round/per plant were applied each day at 2300, 2400 and 0100 h for the night watering treatment, at 0800, 0900 and 1000 h for the morning treatment and at 1500, 1600 and 1700 h for the afternoon treatment.

Neither the increased volume of the extra waterings or their timing had any significant effect on yield or percentage Class 1 fruit.

The extra waterings did, however, result in reduced levels of soluble solids and dry matter in fruit early in the season and also reduced levels of Gold Spot.

There were no interactions between growing systems, medias and irrigation regimes. The V-System yields were as high as those for the Double Rows for most of the season. Percentage run-off was higher for the V-System. Grodan rockwool yielded slightly higher than the Cultilene rockwool or glasswool and produced much lower percentage run-off.

INTRODUCTION

Work done at HRI Efford during 1991-1992 quantified the effect of irrigation frequency by day in combination with the presence or absence of night waterings and the use of reduced rockwool volumes, namely the V-System.

The presence of night waterings had the effect of increasing yield by 1.59 kgm^{-2} (10.52%) to the end of May and 3.46 kgm^{-2} (6.85%) to the end of September in the 1991/1992 season. However, it was not possible from that trial to separate the effects of additional volume (3 applications of 100mls per day) from the timing of the applications.

Many growers are now using the V-System of training tomato plants which reduces the volume of substrate available to the roots. Irrigation regimes which work well for the conventional Double Row growing system may not be the most suitable for the V-System. In the 1991/1992 HDC Irrigation trial the Double Rows outyielded the V-System by 2.93 kgm^{-2} (5.79%) to the end of September.

OBJECTIVES

To determine the effects, if any, of time of application of extra volumes of feed solution on tomato plant development, yield and fruit quality. To investigate whether the choice of substrate and growing system result in any differences in plant performance and the amount of feed solution running to waste under the different irrigation regimes.

MATERIALS AND METHODS

Site Details

The trial was done at HRI Efford utilising the F-Block facility. The layout of the trial is illustrated in Appendix I, page 27.

Treatments

The main treatments comprised four irrigation regimes.

1. No extra watering.
   A 'standard regime' of 150 ml per plant (200 ml early season) / 100 J cm^{-2} incident radiation as measured by an externally mounted Kipp solarimeter.

2. Extra water at night.
   As (1) above with three additional waterings of 100 ml/plant at 23.00 24.00 and 01.00 h.

3. Extra water in the morning.
   As (1) above with three additional waterings of 100 ml/plant at 08.00, 09.00 and 10.00 h.

4. Extra water in the afternoon.
   As with (1) above with three additional waterings of 100ml/plant at 15.00, 16.00 and 17.00 h.

Sub treatments.

(substrate x growing system)

(i) Grodan Rockwool
(ii) Cultilene Rockwool
(iii) Cultilene Glasswool

each of the above substrates were tested as:

(i) Double Row
(ii) V-System

Cultural Techniques

Seeds of tomato *(Lycopersicon esculentum Mill)* cv Calypso were sown on 3 November 1992, in rockwool multiblocks (40 x 40 x 40mm) which had been wetted up the day before using a feed solution with a pH of 5.0 and an EC of 1,500 μS. Following germination the EC was raised to 2,500 μS coincident with expansion of the cotyledons. Prior to blocking on, ten days after sowing, the 0.65 litre rockwool blocks were wetted up with a feed of pH 5.0 and an EC of 2,500 μS, the aim being to achieve a stable block pH of circa 6.0.

From blocking on to the time taken for the third true leaf to reach 10mm in length, the EC of the applied feed was raised from 2,500 to 3,500 μS. The EC was then raised to 5,000 μS in preparation for slab contact on 4 January 1993.

Modified 'Blueprint' temperatures were applied throughout propagation.

The 'Blueprint regime'

Stage		Target Air Temperatures °C		
		Day	Night	Vent
0.	**Sowing to Germination**	24	24	26
1.	**Germination to blocking on**	20	20	24
2.	**Blocking on to 1st visible bud**	20	16	24

The CO_2 level in the glasshouse was raised from ambient to a target 1,000 vpm (sunrise to sunset; using pure CO_2).

V-System plants were knocked over on 14 December and plants were strung to a 3 m crop wire and layered on reaching wire height. The initial plant density was 2.62 plants/m^2 or 10,600 plants/acre. Sideshoots were taken from one in four plants in week 11 to produce a final population at 3.27 plants/m^2 or 13,250 plants/acre. In all respects crop management followed best commercial practice. Full details of the crop diary, including pest disease control are listed in Appendix II, pages 28-29.

Assessments

The following records were taken during the course of the trial.

- Graded and total marketable yield, percentage Class I, II and Waste fruit.
- Date of first anthesis, first fruit pick, number of fruits set and number marketable on trusses 1-10 for four plants per plot.
- Severity of fruit physical disorders.
- Shelf-life potential of fruit
- Measurement of applied and run-off volumes for all treatments.
- Routine analysis of applied and slab solution for nutritional content.
- Daily monitoring of applied and slab solution pH and EC.
- Full monitoring of the glasshouse aerial environment.
- Photographic record of the crop.

Fruit Quality Assessment Methods

Disorder Assessments

Ten fruit were sampled at random from each plot and each fruit assessed for the following disorders.

Boxiness (hollow fruit)
Slab-sidedness
Ribbing
Nippling
Netting (fine net cracking)
Concentric cracking
Gold spot (calyx end)
Gold Marbling (flecking - blossom end)
Red Noses
Blotchy ripening
Laddering (Gooseberry veining)
Squat fruit

Disorders were scored from 0 (none) - 4 (severe) for each of the 10 fruit and a mean score calculated for each plot.

Shelf-life Assessments and Chemical Analysis

Fruit were sampled at ATB Colour stage 4. Where possible 10 Class 1, Grade D fruit were chosen. However when fruit picks were small or when fruit did not fulfil the above criteria, fewer fruit were selected or Size C or E fruit included.

Tomatoes were passed through a handling simulator (500-600mm drop) and placed in plastic trays in the shelf life room where they remained for 6 days. The shelf life room was maintained at around 20°C and 50-60% Relative Humidity, with 12 hours of fluorescent lighting per day.

The sample of fruit for each plot was weighed at the beginning and the end of the shelf life period and the percentage weight loss calculated for the plot.

At the end of the shelf life period, the calyx was removed from each individual fruit before measurement of its compression (mm) under a 1kg load in a firmness meter. A mean compression was calculated for each plot.

Fruit were taken at the end of the shelf-life assessments and divided for dry weight determination and acidity and soluble solids determinations.

% Dry Weight: For each plot, quarters from each of 5 fruit were placed in a tray, weighed and then dried in an oven at 60°C for 3 days. The samples of fruit were weighed again and the percentage dry matter calculated taking into account the percentage weight loss during shelf-life.

% Soluble Solids: The remaining tomatoes, not used in the dry matter determinations, were placed in plastic bags (one for each plot) and frozen. After thawing, fruit was pulped by hand and filtered for 2 hours to separate the juice. Two measurements of percentage soluble solids of the juice were made for each plot using a sugar refractometer (range 0-10% Brix) and an average taken. Readings were adjusted according to the temperature of the solution.

Acidity: This was determined by dissolving 0.38g tri-sodium orthophosphate $Na_3PO_4.12H_2O$) in 20ml filtered juice and after 10 minutes measuring the endpoint pH with a hand held pH meter.

Experimental Design and Explanation of Statistical Terms

The 24 treatments (4 irrigation regimes x 2 growing systems x 3 substrates) each comprised two replicates. The 48 plots were arranged in a balanced row and column design (refer to trial plan, Appendix I). A full analysis of variance was carried out and hence differences between treatments were assigned statistical significance.

Throughout the main body of this report and selected appendices a number of statistical terms are referred to; these are:-

SED = The standard error of the difference when comparing two means in that column of data

A statistical term easier to interpret:

LSD 5% = The least (minimum) difference when comparing two means within a given column that is required for the means to be statistically different.

N.S = Not significant

* = <0.05, i.e. the probability of this result occurring by chance is equal to or less than 1 in 20 ($0.05=5\%$).

** = $P<0.01$, i.e. the probability of this result occurring by chance is equal to or less than 1 in 100 ($0.01=1\%$).

*** = $P<0.001$, i.e. the probability of this result occurring by chance is equal to or less than 1 in 1000 ($0.001=0.1\%$).

RESULTS

Plant Growth and Development

The treatments generally had no effect on the time taken for the plants to reach first anthesis on trusses 1 - 10. The time taken for the fruit to develop was similarly unaffected by the treatments. Date of first anthesis and first pick on trusses 1 - 10 are listed in Appendix III, page 30.

There were no significant differences in the number of fruit set or the number of marketable fruit on trusses 1 - 10 between the irrigation regimes. However, more fruit per truss were set and more marketable for the Double Rows than the V-System (Table 1, page 12).

Yield and Gradeout

The night watering treatment produced the highest yield, 17.33 kgm^{-2} to the end of May and 50.5 kgm^{-2} to the end of September but differences between treatments were not significant (Tables 2 and 3, page 13). The Double Rows produced higher yield than the V-System in March but for the rest of the season yields were similar (Table 4, page 14). There was a slight difference in yield between the medias. Grodan rockwool yielded consistently more than Cultilene rockwool and Cultilene glasswool yielded the lowest throughout the season but differences were only significant in April and July (Table 5, page 14). Overall differences to end of September between substrates were no bigger than the differences between irrigation regimes.

The gradeout figures were similar for all treatments and sub-treatments. (Appendices IV-XI, pages 31-38).

Fruit Quality

Levels of Physical Disorders

Fruit shape, ripening disorders and other disorders were generally unaffected by the treatments and sub-treatments. The only apparent effect of the extra waterings was to reduce levels of Gold Spot (Fig 1, page 15). The lowest levels of Gold Spot were recorded in the extra water at night treatment. However differences were not significant. (See Appendix XII, page 39).

Shelf-life

The treatments and sub-treatments had little effect on fruit softness or weight loss after 6 days storage.

Internal Composition

The 'no extra' water treatment resulted in fruit with higher levels of soluble solids and higher percentage dry matter for the first half of the season (Figures 2 and 3, pages 16 and 17). However, the effect did not persist throughout the whole season and differences were not generally statistically significant. The data for soluble solids and dry matter content are listed with levels of statistical significance in Appendices XIII and XIV, pages 40 and 41.

Run-off Percentages

For the early part of the season (up to week 25) the no extra waterings treatments produced the smallest percentage run-off figures (Figure 4, page 18). However, this effect did not persist. Unfortunately problems were encountered recording run-off data from the extra water at night treatment and that data is therefore not presented.

There were marked differences in the percentage run-off from the 2 growing systems. The V-System resulted in consistently higher run-off (Figure 5, page 19). Similarly, there were marked difference between substrates. Grodan rockwool resulted in lower run-off than the Cultilene rockwool and glasswool. While differences between the Cultilene medias were negligible from week 18 onwards, before that the glasswool media produced much higher run-off (Fig 6, page 20).

Applied Volumes and Slab Environment

Figure 7, page 21, shows the average volume of feed applied per plant per week for each treatment as measured by flow meters in the irrigation line. The projected volume, based upon the number of waterings triggered by light (excluding extra waterings) and the intended volume of each watering, is also plotted. It can be seen that similar volumes were applied on all treatments except that slightly lower volumes were applied to the no extra watering treatment as planned, and that the extra water night treatment received too much water up until week 22. These differences are reflected in the slab environment. The conductivity in Grodan slabs on the Double Row system was consistently higher for the no extra watering treatment and lower for the extra water at night treatment, particularly early in the season (Figure 8, page 22). The extra water at night treatment slabs were more acidic than the others, closer to the pH of the applied feed (Figure 9, page 23). Differences in slab environment between growing systems and medias were not consistent.

Table 1 **Effect of irrigation regime and growing system on the average number of fruit set and marketable on trusses 1-10**

Irrigation regime	Number set	Number marketable
No extra watering	9.14	7.92
3 x 100mls @ 23, 24, 01 h	9.56	8.17
3 x 100mls @ 08, 09, 10 h	9.53	8.05
3 x 100mls @ 08, 09, 10 h	9.53	8.05
3 x 100mls @ 15, 16, 17 h	9.22	7.61
SED (3 d.f)	*0.134*	*0.277*
LSD	*0.315*	*0.652*
Significance	*N.S.*	*N.S.*

Growing system	Number set	Number marketable
Double Row	9.49	8.13
V-System	9.24	7.74
SED (3 d.f)	*0.061*	0.073
LSD	*0.144*	0.172
Significance	*	*

Table 2 Effect of irrigation regime on total yield, percentage Class I fruit and grade out to the end of May.

Irrigation regime	Total yield kg/m²	% Class I fruit	% Class I fruit in size grade C >57mm	D 47-57mm	E 40-47mm
No extra waterings	16.65	91.0	14.5	74.4	10.5
3 x 100mls @ 23, 24, 01 h	17.33	90.6	16.1	74.0	9.3
3 x 100mls @ 08, 09, 10 h	16.59	90.6	15.3	73.6	10.5
3 x 100mls @ 15, 16, 17 h	16.55	90.4	13.8	75.0	10.5
SED (3 d.f)	*0.94*	*0.40*	*3.85*	*2.53*	*1.36*
LSD (5%)	*2.21*	*0.94*	*9.06*	*5.95*	*3.20*
Significance	*N.S*	*N.S*	*N.S*	*N.S*	*N.S.*

Table 3 Effect of irrigation regime on total yield, percentage Class I fruit and grade out to the end of September.

Irrigation regime	Total yield kg/m²	% Class I fruit	% Class I fruit in size grade C >57mm	D 47-57mm	E 40-47mm
No extra waterings	48.93	89.2	17.9	72.6	8.8
3 x 100mls @ 23, 24, 01 h	50.50	89.3	17.8	72.4	9.0
3 x 100mls @ 08, 09, 10 h	49.88	90.3	17.1	73.1	9.0
3 x 100mls @ 15, 16, 17 h	47.95	89.9	17.1	72.9	9.3
SED (3 d.f)	*0.65*	*0.88*	*3.07*	*1.99*	*1.15*
LSD (5%)	*1.52*	*2.07*	*7.22*	*4.68*	*2.70*
Significance	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*

Table 4 Effect of growing system on total yield (kgm^{-2})

Growing System	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Double Row	2.58	5.87	8.57	9.05	9.08	7.68	6.92	49.74
V-System	2.19	5.54	8.81	9.03	9.05	7.60	6.67	48.88
SED (3 d.f)	*0.089*	*0.125*	*0.158*	*0.145*	*0.112*	*0.068*	*0.027*	*0.513*
LSD 5%	*0.209*	*0.294*	*0.372*	*0.341*	*0.264*	*0.160*	*0.064*	*1.207*
Significance	*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	**	*N.S.*

Table 5 Effect of substrate on total yield (kgm^{-2})

Substrate	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Grodan rockwool	2.54	5.83	8.84	9.09	9.25	7.78	6.89	50.22
Cultilene rockwool	2.29	5.74	8.63	9.10	9.04	7.63	6.83	49.26
Cultilene glasswool	3.32	5.55	8.59	8.94	8.90	7.50	6.66	48.47
SED (16 d.f)	*0.103*	*0.084*	*0.168*	*0.173*	*0.130*	*0.133*	*0.169*	*0.664*
LSD (5%)	*0.214*	*0.174*	*0.349*	*0.359*	*0.270*	*0.276*	*0.351*	*1.378*
Significance	*N.S.*	*	*N.S.*	*N.S.*	*	*N.S.*	*N.S.*	*N.S.*

Figure 1.

Effect of irrigation regime on levels of Gold Spot

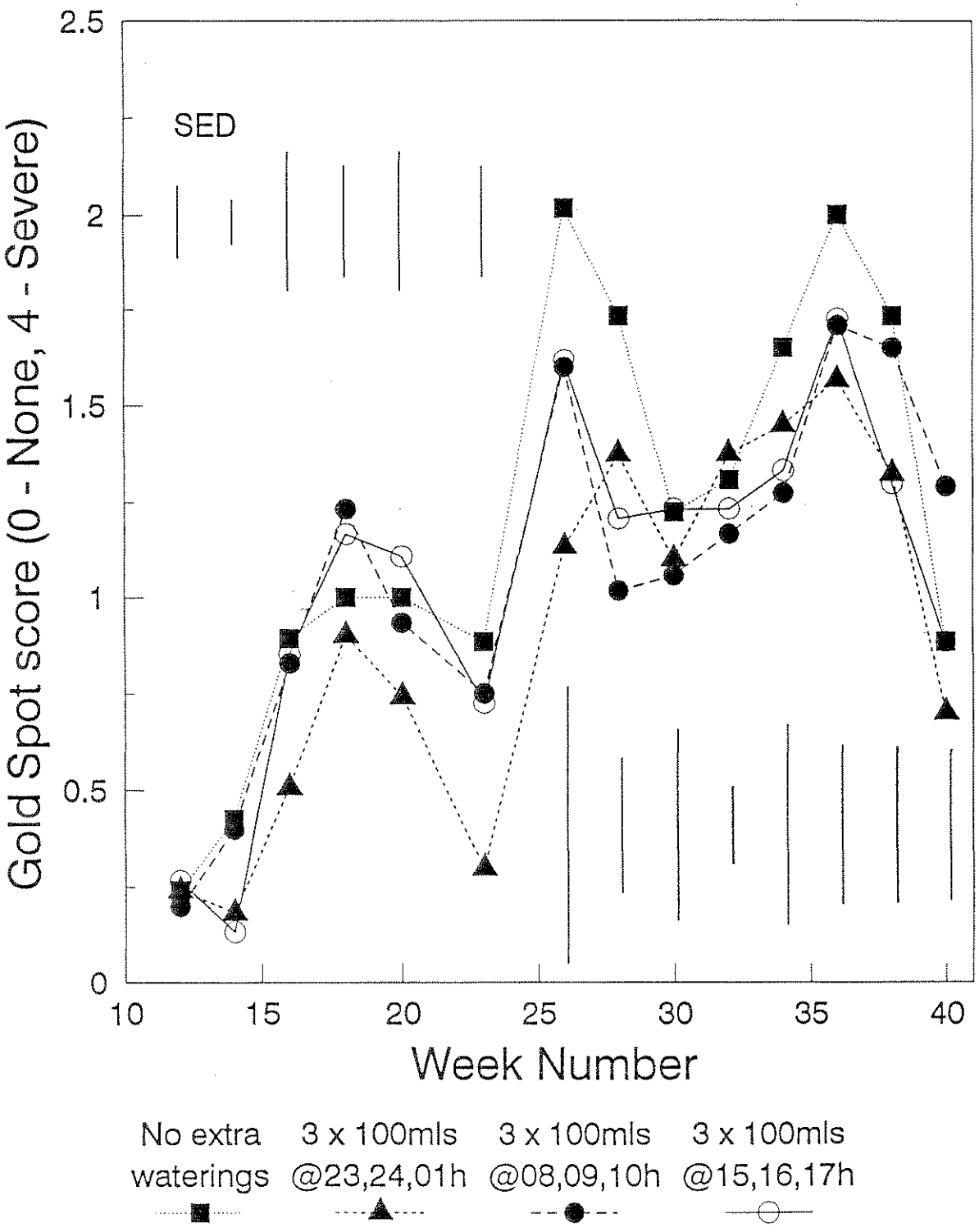


Figure 2.

Effect of irrigation regime on levels of soluble solids in fruit

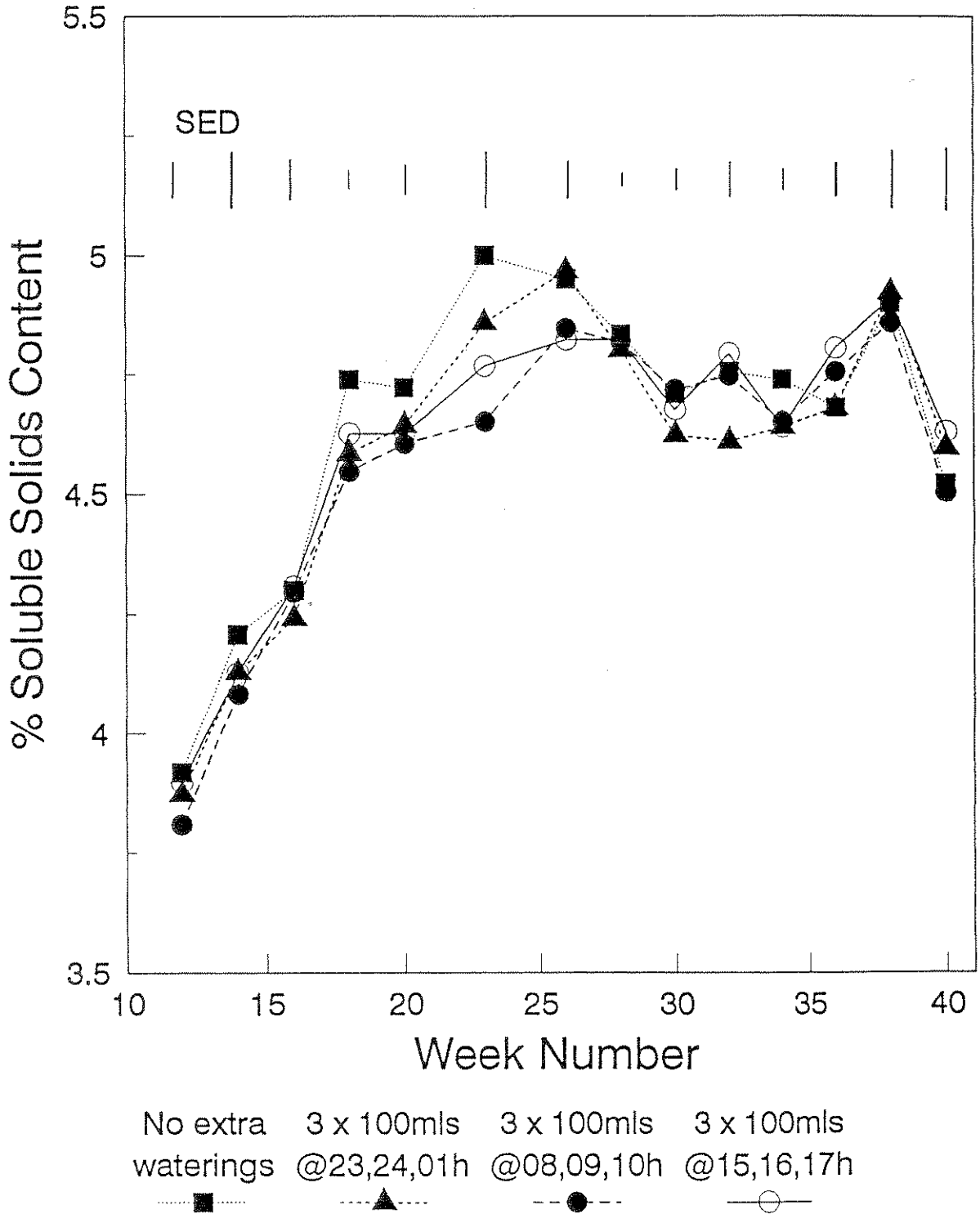


Figure 3.

Effect of irrigation regime on fruit dry matter content

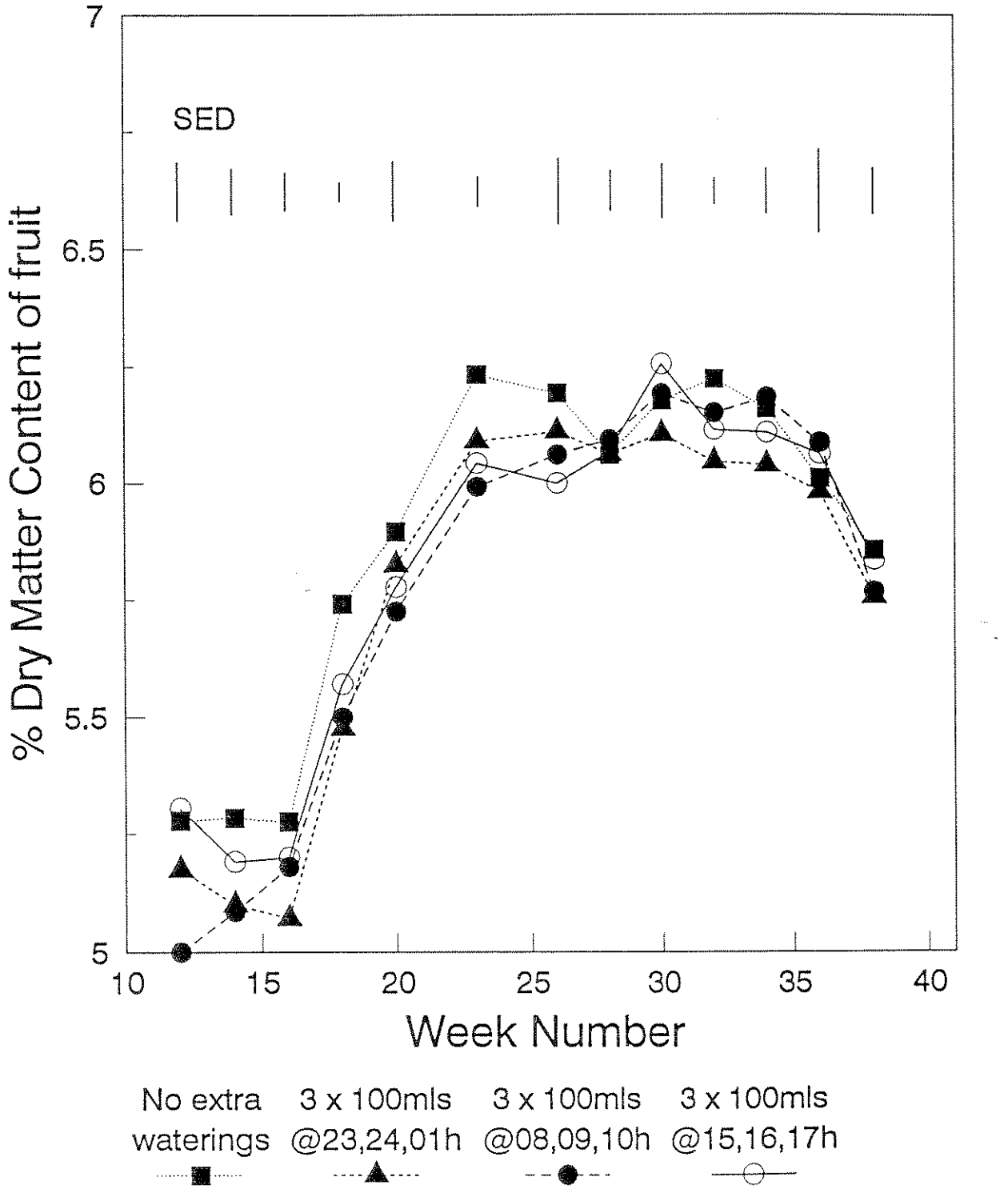


Figure 4.
Effect of irrigation regime on % run-off
(excluding the 3 x 100mls @ 23, 24, 01 h treatment)

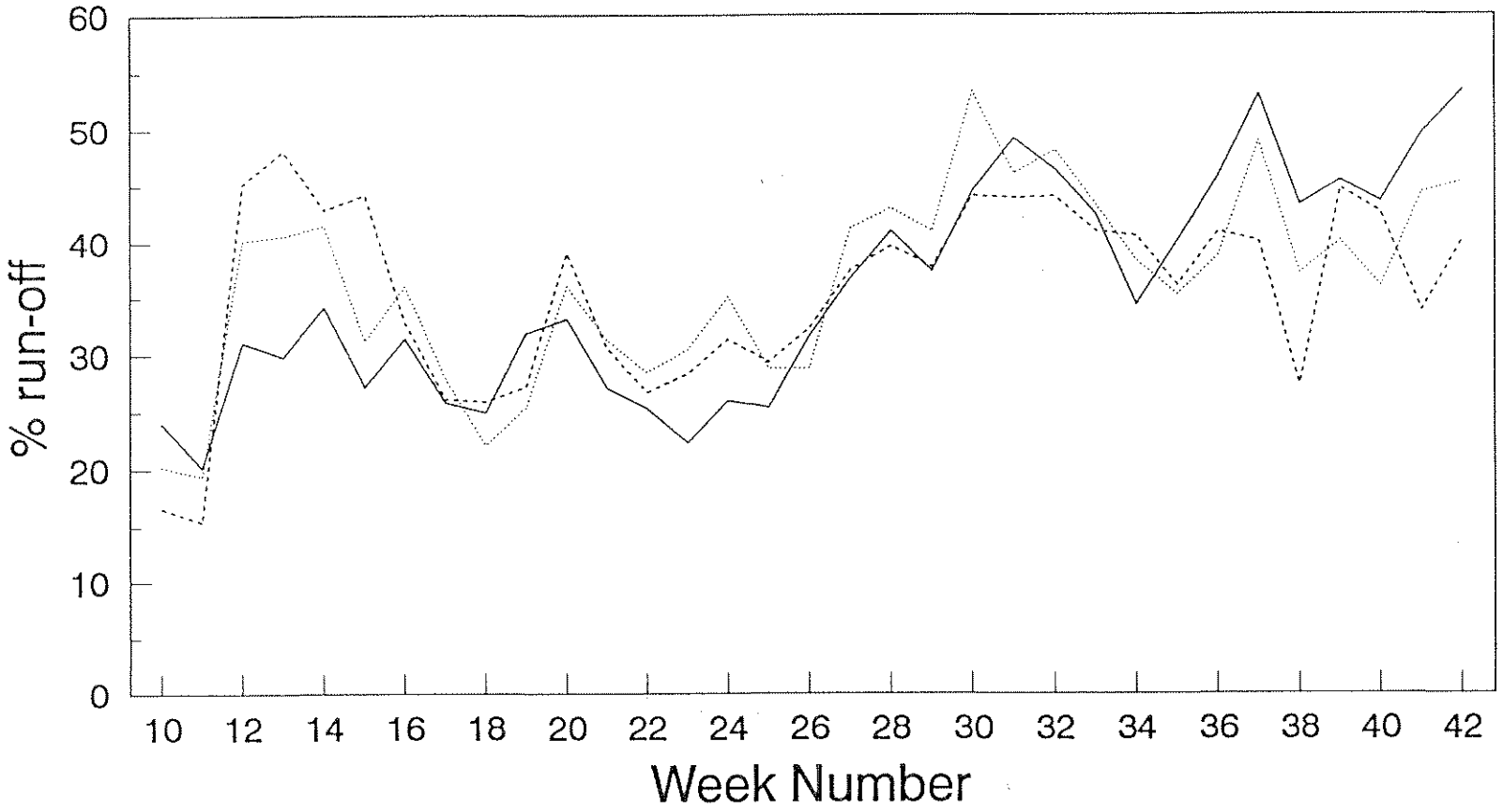


Figure 5.
Effect of Growing regime on % run-off
(excluding data from the 3 x 100mls @ 23, 24, 01 h treatment)

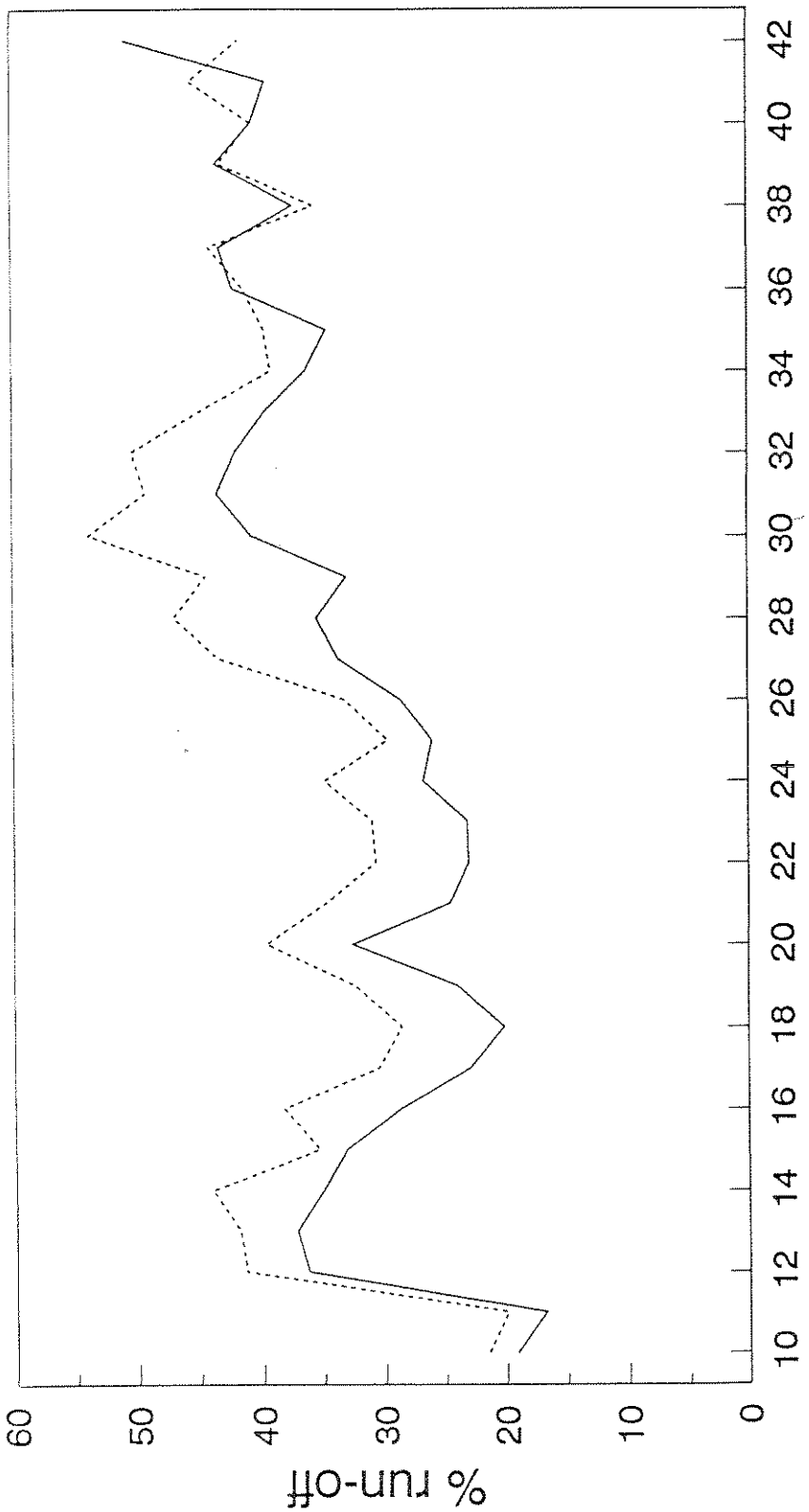


Figure 6.
Effect of Substrate media on % run-off
(excluding 3 x 100mls @ 23, 24, 01 h treatment)

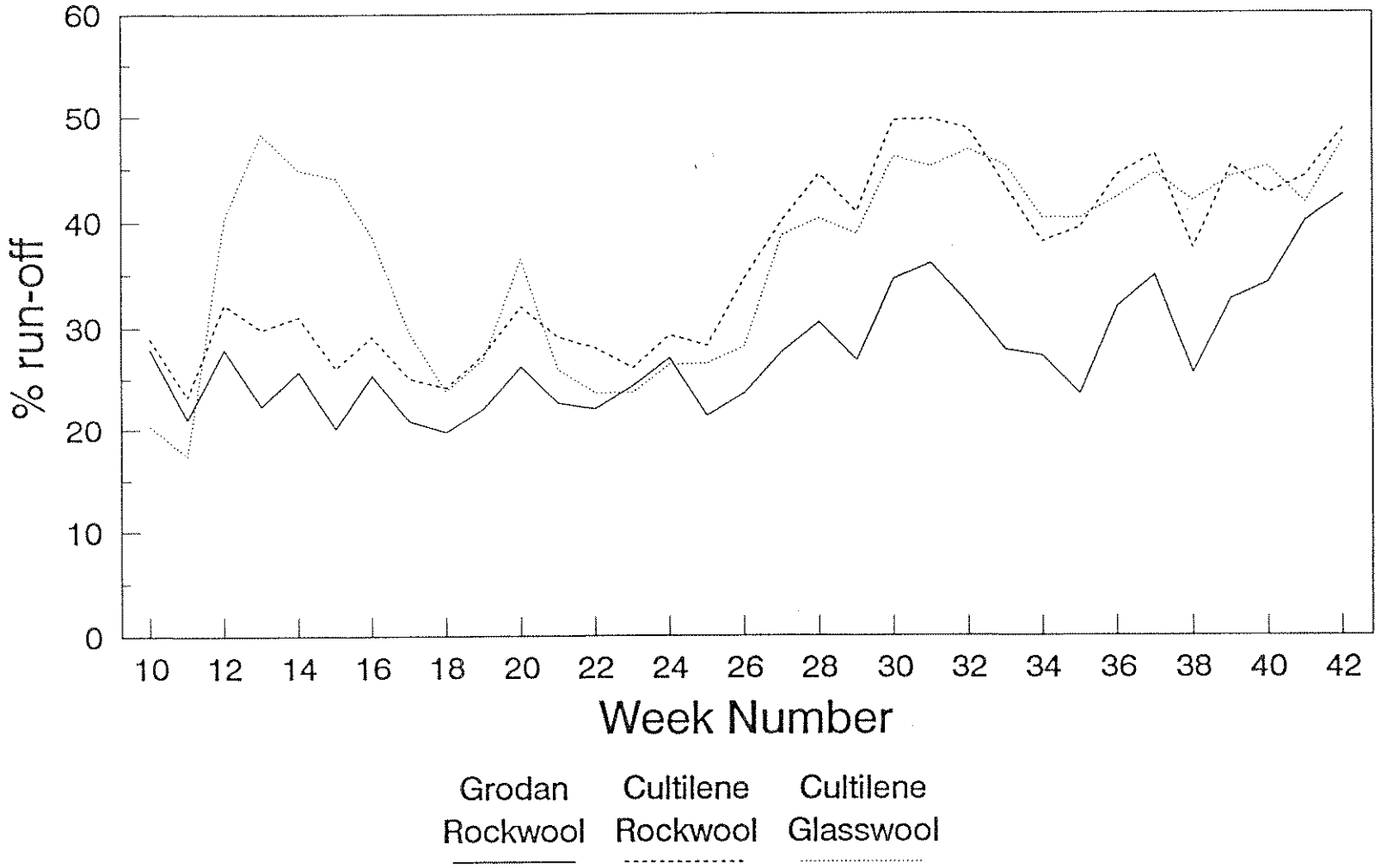
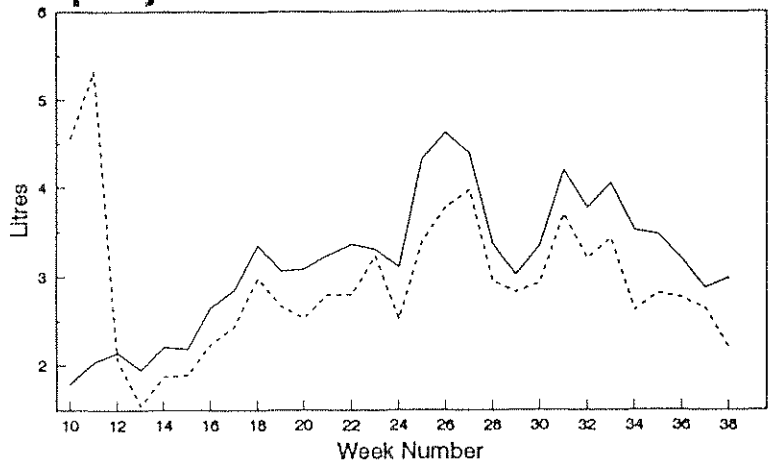
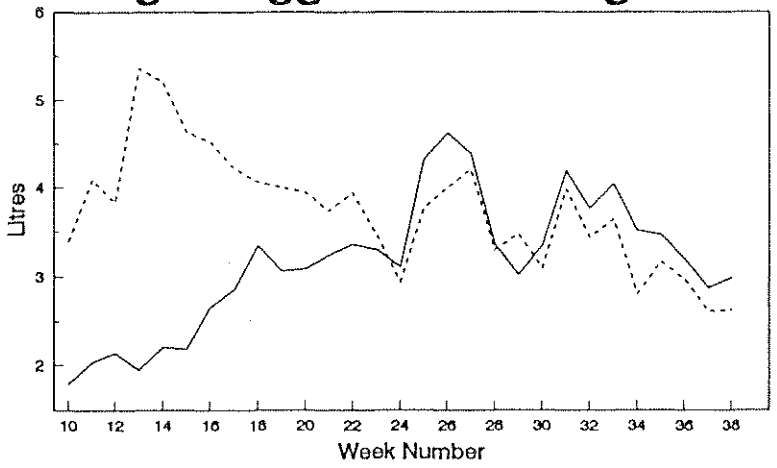
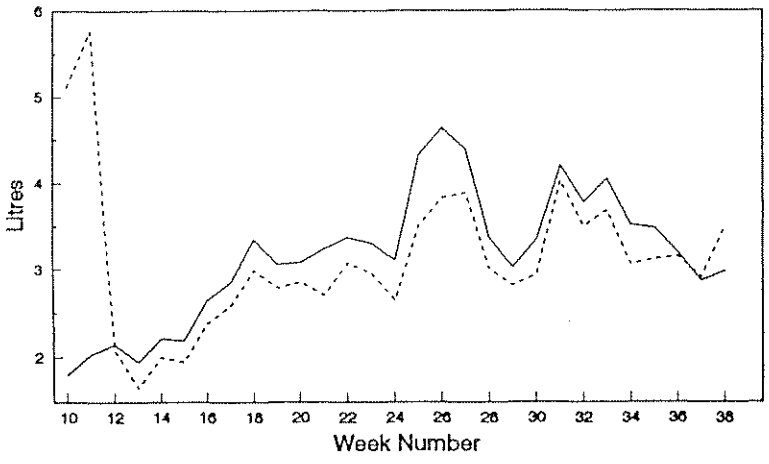


Figure 7.
Effect of irrigation regime on litres applied per plant per day compared to projected litres based on the number of light triggered waterings







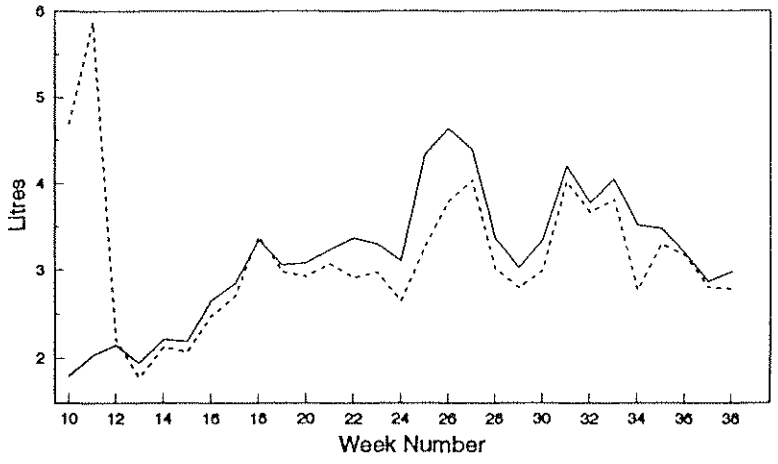


Figure 8.
Conductivities for the 4 irrigation regimes in Grodan slabs on the Double row growing system

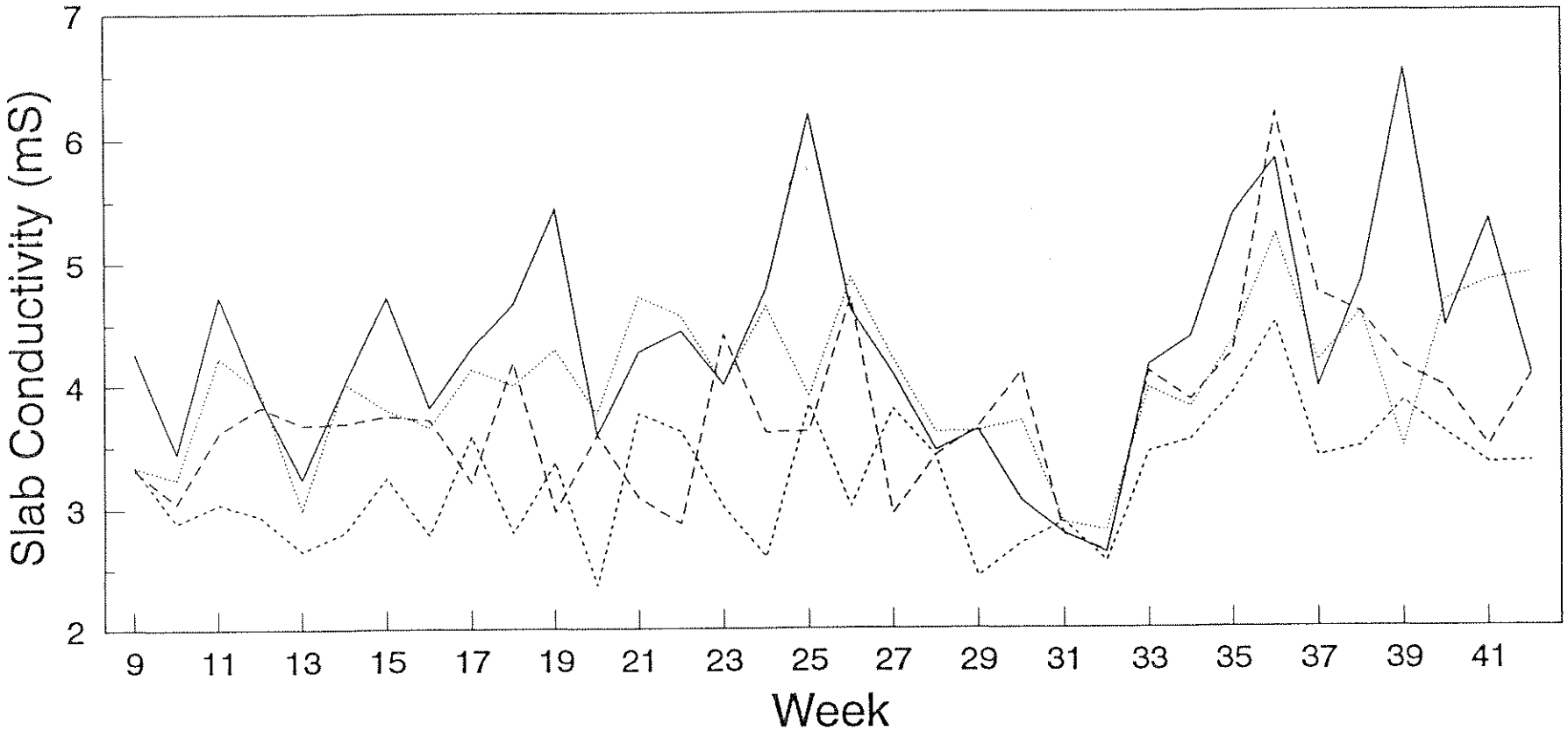
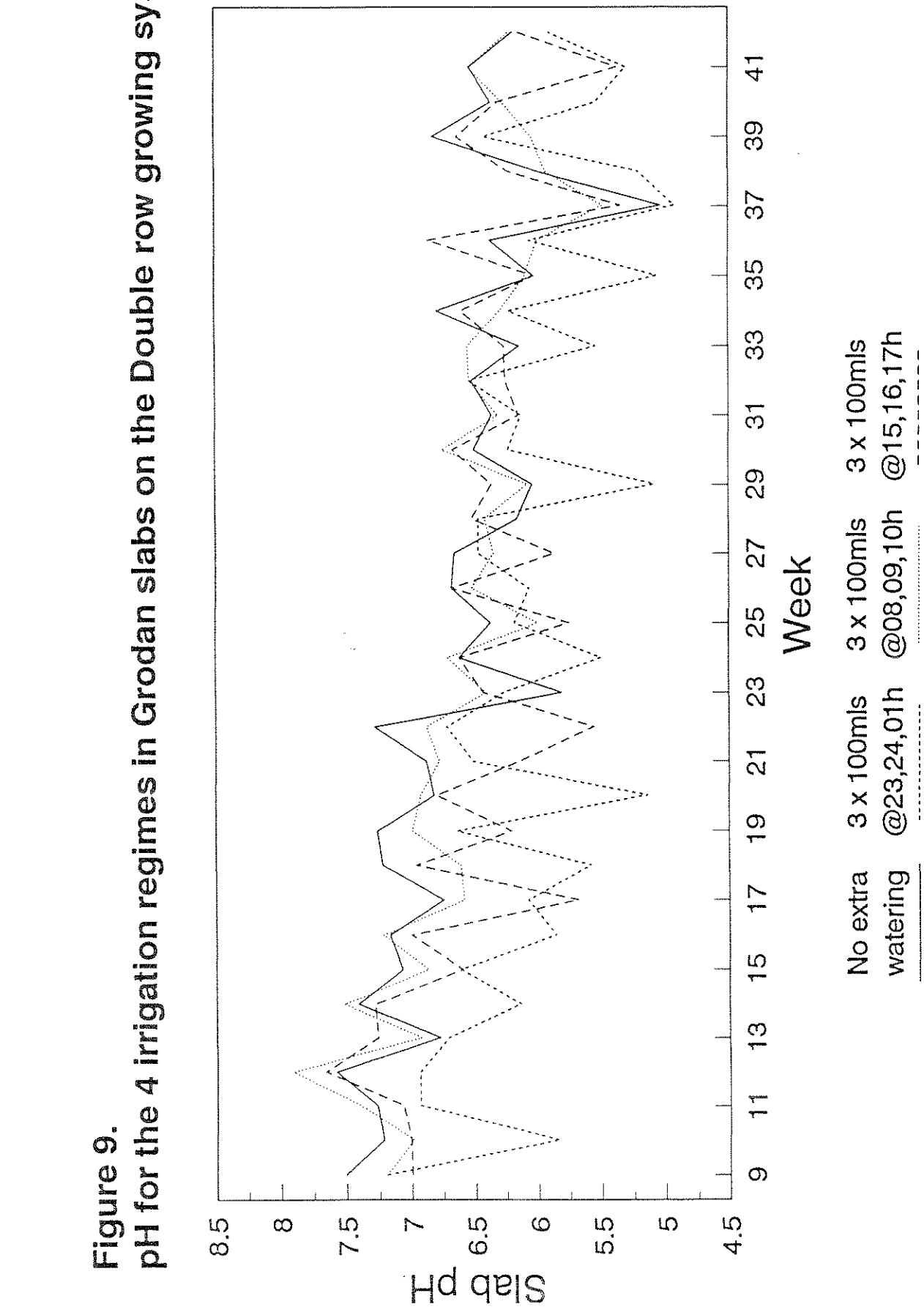


Figure 9.
pH for the 4 irrigation regimes in Grodan slabs on the Double row growing system



DISCUSSION

The 1992/93 irrigation trial, reported here, found no significant differences in yield between 'extra watering treatments' and a 'no extra watering treatment' (control) or between extra waterings applied at different times of day. The highest yielding treatment was the extra water at night treatment but additional yield may have been a result of a minor fault with the irrigation system which allowed slightly higher volumes to be applied than was intended. The lack of any significant differences between the irrigation regimes suggests that the standard 150ml per 100 J cm^{-2} was more than adequate in providing the plants with enough water.

The 1991/92 irrigation trial at Efford revealed higher yields from a night watering sub-treatment across all four of the main irrigation frequency treatments. However, the size of the difference in yield was not consistent across these main treatments (Table 6, page 26). The difference between the no night watering treatment and the night watering treatment was greatest under the least frequent (400ml per application) treatment. It is perhaps not surprising then that under the 1992/93 standard regime of 150ml per application any benefits of night watering were small.

The higher dry matter and soluble solids content of the no extra watering treatment early in the season is coincident with higher slab conductivity. Early in the season the absence of extra waterings would have been significant, however, later, as a greater number of waterings were triggered by light the extra watering became less important and the difference between no extra water and extra water treatments diminished.

In 1991/92 the Double Rows outyielded the V-System by nearly 6% to the end of September. In 1992/93 the difference was only 1.8%, the V-System performing less well at the start of the season. The V-System heads are lower than the Double Row heads until they reach wire height due to the plants having been knocked over. For this reason the Double Row plants are likely to have received better light conditions early in the season. In addition V-System plants would have benefitted more from a lower starting population than was used in this experiment. The increased run-off from the V-System compared to the Double Rows was expected due to the reduced slab volume. The fact that the extra run-off was not coincident with reduced yield in the V-System is further evidence that the crop was receiving more than enough water.

A difference in yield between medias was evident in the first half of the season. The Grodan rockwool outyielded the Cultilene rockwool and glasswool. However, the watering regimes employed in the trial were likely to favour the Grodan rockwool. A regime of more frequent waterings of lower volume might have benefitted the Cultilene substrates.

CONCLUSIONS

1. The application of extra waterings had little impact on yield in this trial where 150ml/100 J cm^{-2} incident radiation were applied to each plant.

2. The extra waterings reduced the soluble solids and dry matter content of fruit early in the season.

3. The timing of applications of extra water had no effect on yield or fruit quality.

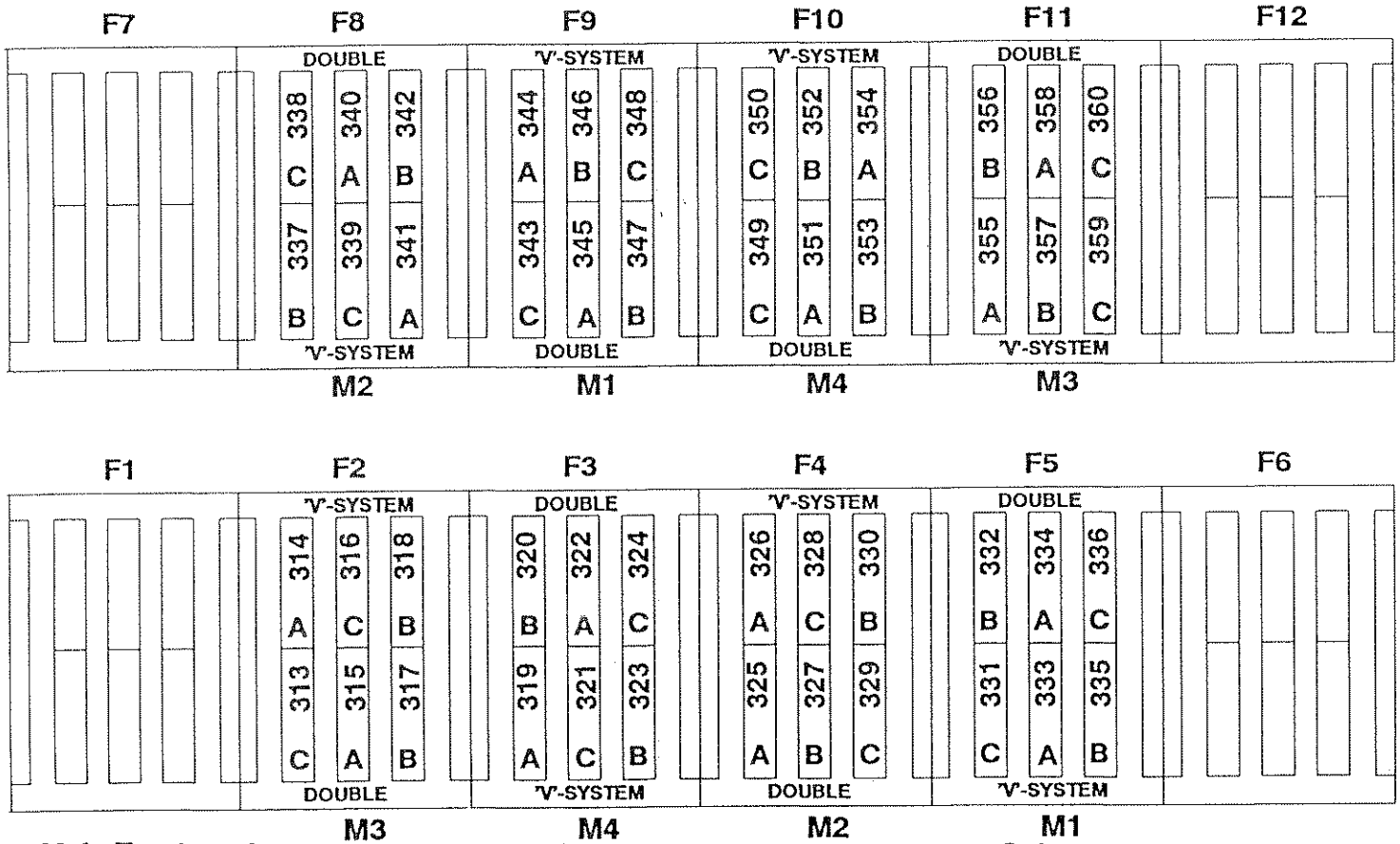
4. The V-System performed as well as the Double Rows, except very early in the season. Higher percentage run-off was recorded for the V-System.

5. There were marked differences in percentage run-off and slight differences in yield between substrates under the irrigation regimes imposed.

Table 6 The effect of extra water at night on total yield (kgm^{-2}) in the 1991/92 irrigation trial for the four irrigation frequencies.

Volume per application (same volume/day)	No extra water	Extra Water at night
50ml	47.48	49.40
100ml	48.99	49.23
200ml	47.45	52.12
400ml	44.70	51.79

HDC IRRIGATION TRIAL 1992/1993
PLAN OF TREATMENTS (F-BLOCK)



Appendix 1.

Main Treatments

M1 - No extra waterings
M2 - 3 x 100ml extra @ 23, 24 & 01hrs
M3 - 3 x 100ml extra @ 08, 09 & 10hrs
M4 - 3 x 100ml extra @ 15, 16 & 17hrs

Media

A - Grodan
B - Cultilene
C - Glasswool

Variety - Calypso
Plant Spacing - 476mm
20 plants/plot Plot area = 7.61m²
Initial population 2.62 plants/m² or 10,600/acre

APPENDIX II

Crop Diary

Seed Sown	3.11.92
Plants moved to final position	10.12.92
Slab contact	7.01.93
Treatments commenced	14.02.93
First fruit picked	24.02.93
Sideshoots taken on 1 in 4 plants	11.03.93
Stopped heads	10.09.93
Final recorded pick and end of trial	28.10.93

Pest and Disease Control

A number of beneficial insects were introduced to combat the following pests:-

Predator	Pest
Encarsia formosa	whitefly
Dacnusa/Diglyphus	leaf miner
Aphidius	aphids
Anagrus atomus	leafhopper

Insecticide applications

Product	Date	Target
Torque (Fenbutatin oxide)	19.06.93	red spider mite
Savona (Fatty acids)	01.07.93	whitefly
Torque (Fenbutatin oxide)	06.07.93	red spider mite
Savona (Fatty acids)	14.07.93	whitefly
Torque (Fenbutatin oxide)	16.07.93	red spider mite
Savona (Fatty acids)	20.07.93	whitefly
Savona (Fatty acids)	29.07.93	whitefly
Torque (Fenbutatin oxide)	09.08.93	red spider mite
Torque (Fenbutatin oxide)	27.08.93	red spider mite
Childion (Dicofel & tetradifon)	08.10.93	red spider mite
Hostaquick (Heptenophos)	22.10.93	leafhopper
Childion (Dicofel & tetradifon)	29.10.93	red spider mite

Fungicide applications

Product	Date	Target
Rubigan (fenarimol)	07.03.93	Powdery mildew
Elvaron (dichlofluanid)	12.03.93	Botrytis
Thiovit (sulphur)	26.03.93	Powdery mildew
Bravo (chlorothalonil)	03.04.93	Botrytis
Rovral (iprodione)	16.04.93	Botrytis
Bravo (chlorothalonil)	01.05.93	Botrytis
Bravo (chlorothalonil)	15.05.93	Botrytis
Elvaron (dichlofluanid)	28.05.93	Botrytis
Bravo (chlorothalonil)	23.07.93	Botrytis
Bravo (chlorothalonil)	05.08.93	Botrytis
Rovral (iprodione)	20.08.93	Botrytis
Rovral (iprodione)	17.09.93	Botrytis

APPENDIX III

Effect of irrigation regimes on the date of first anthesis and first pick on trusses 1 - 10.

Irrigation regime	Day number of first anthesis Truss 1	2	3	4	5	6	7	8	9	10
No extra waterings	364	10	19	27	39	47	55	63	69	76
3 x 100mls @ 23, 24, 01 h	367	12	21	30	40	48	55	63	69	76
3 x 100mls @ 98, 09, 10 h	367	12	20	30	40	48	55	63	70	76
3 x 100mls @ 15, 16, 17 h	366	12	20	29	40	48	55	62	69	75
SED (3 d.f)	*0.693*	*0.837*	*0.816*	*1.434*	*1.091*	*0.795*	*0.655*	*0.444*	*0.628*	*0.475*
LSD (5%)	*1.631*	*1.969*	*1.920*	*3.374*	*2.567*	*1.871*	*1.541*	*1.045*	*1.478*	*1.118*
Significance	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*

Irrigation regime	Day number of first pick Truss 1	2	3	4	5	6	7	8	9	10
No extra waterings	64	77	85	92	100	106	113	120	126	131
3 x 100mls @ 23, 24, 01 h	68	79	86	93	101	107	114	120	126	131
3 x 100mls @ 98, 09, 10 h	68	78	86	94	101	107	114	120	127	133
3 x 100mls @ 15, 16, 17 h	67	78	87	93	100	106	113	120	126	132
SED (3 d.f)	*0.947*	*1.559*	*0.666*	*0.697*	*0.571*	*0.767*	*0.478*	*0.205*	*0.834*	*0.506*
LSD (5%)	*2.228*	*3.668*	*1.567*	*1.640*	*1.343*	*1.805*	*1.125*	*0.482*	*1.962*	*1.191*
Significance	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*

APPENDIX IV

Effect of irrigation regimes growing system and substrate on total yield (kgm^{-2})

Irrigation regime	Growing system	Substrate	Mar	Apr	May	Jun	Jul	Aug	Sep	to end Sep
No extra waterings	Double Row	Grodan rockwool	3.05	6.00	8.48	8.75	8.76	7.76	6.79	49.58
No extra waterings	Double Row	Cultilene rockwool	2.54	5.83	8.28	9.09	8.85	7.89	6.74	49.22
No extra waterings	Double Row	Cultilene glasswool	2.60	5.57	8.21	8.99	8.49	7.60	6.66	48.12
No extra waterings	V-System	Grodan rockwool	2.29	5.76	8.90	9.52	9.16	7.94	6.76	50.32
No extra waterings	V-System	Cultilene rockwool	2.06	5.41	9.12	9.32	8.96	7.22	6.64	48.73
No extra waterings	V-System	Cultilene glasswool	2.11	5.44	8.25	8.73	8.84	7.62	6.62	47.61
3x100mls @ 23,24,01h	Double Row	Grodan rockwool	2.62	5.99	9.34	9.98	9.57	8.03	6.82	52.34
3x100mls @ 23,24,01h	Double Row	Cultilene rockwool	2.51	5.94	9.09	9.55	9.22	7.87	7.15	51.33
3x100mls @23,24,01h	Double Row	Cultilene glasswool	2.28	5.81	9.49	9.89	9.44	7.54	6.93	51.38
3x100mls @ 23,24,01h	V-System	Grodan rockwool	2.42	5.83	9.27	9.22	9.28	7.89	6.79	50.68
3x100mls @ 23,24,01h	V-System	Cultilene rockwool	2.18	5.85	8.35	8.98	8.87	7.36	6.94	48.52
3x100mls @ 23,24,01h	V-System	Cultilene glasswool	2.32	5.47	9.23	9.07	8.83	7.37	6.43	48.72
3x100mls @ 08,09,10h	Double Row	Grodan rockwool	2.67	6.04	8.40	8.62	9.18	7.65	7.40	49.95
3x100mls @ 08,09,10h	Double Row	Cultilene rockwool	2.24	5.80	8.45	9.30	9.66	8.24	7.54	51.22
3x100mls @ 08,09,10h	Double Row	Cultilene glasswool	2.49	5.68	8.29	8.59	9.34	7.71	7.31	49.40
3x100mls @ 08,09,10h	V-System	Grodan rockwool	2.31	5.74	9.25	9.28	9.62	8.09	7.37	51.66
3x100mls @ 08,09,10h	V-System	Cultilene rockwool	2.12	5.59	8.21	9.00	9.22	7.71	6.55	48.40
3x100mls @ 08,09,10h	V-System	Cultilene glasswool	2.10	5.55	8.62	9.12	8.88	7.70	6.70	48.67
3x100mls @ 15,16,17h	Double Row	Grodan rockwool	2.70	5.82	8.32	8.57	9.15	7.33	6.40	48.29
3x100mls @ 15,16,17h	Double Row	Cultilene rockwool	2.65	6.35	8.68	8.97	8.85	7.21	6.85	49.55
3x100mls @ 15,16,17h	Double Row	Cultilene glasswool	2.57	5.65	7.82	8.32	8.43	7.30	6.48	46.56
3x100mls @15,16,17h	V-System	Grodan rockwool	2.23	5.46	8.81	8.78	9.31	7.52	6.81	48.92
3x100mls @ 15,16,17h	V-System	Cultilene rockwool	2.01	5.18	8.86	8.56	8.70	7.53	6.24	47.08
3x100mls @ 15,16,17h	V-System	Cultilene glasswool	2.11	5.27	8.80	8.79	8.97	7.20	6.15	47.28

APPENDIX V

Effect of irrigation regimes growing system and substrate on marketable yield (kg/m^{-2})

Irrigation regime	Growing system	Substrate	Mar	Apr	May	Jun	Jul	Aug	Sep	to end Sep
No extra waterings	Double Row	Grodan rockwool	3.00	5.77	8.35	8.56	8.57	7.26	6.56	48.07
No extra waterings	Double Row	Cultilene rockwool	2.50	5.60	8.17	8.87	8.64	7.22	6.49	47.49
No extra waterings	Double Row	Cultilene glasswool	2.55	5.37	8.08	8.78	8.35	7.09	6.37	46.59
No extra waterings	V-System	Grodan rockwool	2.24	5.53	8.80	9.31	8.94	7.33	6.55	48.70
No extra waterings	V-System	Cultilene rockwool	2.01	5.21	8.97	9.13	8.77	6.70	6.41	47.20
No extra waterings	V-System	Cultilene glasswool	2.09	5.21	8.15	8.54	8.68	7.03	6.38	46.08
3x100mls @ 23,24,01h	Double Row	Grodan rockwool	2.57	5.78	9.16	9.71	9.37	7.49	6.63	50.71
3x100mls @ 23,24,01h	Double Row	Cultilene rockwool	2.46	5.71	8.98	9.36	9.02	7.36	7.01	49.91
3x100mls @23,24,01h	Double Row	Cultilene glasswool	2.24	5.56	9.36	9.67	9.26	6.87	6.68	49.64
3x100mls @ 23,24,01h	V-System	Grodan rockwool	2.36	5.68	9.17	9.04	9.07	7.28	6.62	49.23
3x100mls @ 23,24,01h	V-System	Cultilene rockwool	2.08	5.60	8.19	8.75	8.70	6.74	6.73	46.80
3x100mls @ 23,24,01h	V-System	Cultilene glasswool	2.25	5.29	9.13	8.92	8.62	6.73	6.26	47.21
3x100mls @ 08,09,10h	Double Row	Grodan rockwool	2.64	5.87	8.26	8.41	9.02	7.28	7.17	48.65
3x100mls @ 08,09,10h	Double Row	Cultilene rockwool	2.20	5.60	8.33	9.15	9.50	7.81	7.30	49.89
3x100mls @ 08,09,10h	Double Row	Cultilene glasswool	2.46	5.50	8.16	8.42	9.19	7.35	7.06	48.15
3x100mls @ 08,09,10h	V-System	Grodan rockwool	2.23	5.54	9.14	9.09	9.45	7.75	7.11	50.30
3x100mls @ 08,09,10h	V-System	Cultilene rockwool	2.08	5.32	8.06	8.77	9.05	7.38	6.27	46.93
3x100mls @ 08,09,10h	V-System	Cultilene glasswool	2.03	5.34	8.49	8.94	8.76	7.42	6.50	47.46
3x100mls @ 15,16,17h	Double Row	Grodan rockwool	2.64	5.63	8.22	8.39	9.00	6.98	6.13	46.99
3x100mls @ 15,16,17h	Double Row	Cultilene rockwool	2.61	6.16	8.53	8.74	8.70	6.61	6.61	47.95
3x100mls @ 15,16,17h	Double Row	Cultilene glasswool	2.50	5.39	7.68	8.15	8.25	6.86	6.26	45.08
3x100mls @15,16,17h	V-System	Grodan rockwool	2.15	5.30	8.71	8.58	9.14	7.03	6.65	47.56
3x100mls @ 15,16,17h	V-System	Cultilene rockwool	1.96	4.97	8.74	8.38	8.52	7.21	5.99	45.76
3x100mls @ 15,16,17h	V-System	Cultilene glasswool	2.08	5.07	8.67	8.62	8.78	6.70	5.77	45.69

APPENDIX VI

Effect of irrigation regime, growing system and substrate on percentage Class I fruit

Irrigation regime	Growing system	Substrate	Mar	Apr	May	Jun	Jul	Aug	Sep	to end Sep
No extra waterings	Double Row	Grodan rockwool	89	90	94	95	92	74	91	90
No extra waterings	Double Row	Cultilene rockwool	88	88	94	93	91	75	90	89
No extra waterings	Double Row	Cultilene glasswool	87	89	94	93	92	76	91	89
No extra waterings	V-System	Grodan rockwool	85	88	95	93	92	75	92	89
No extra waterings	V-System	Cultilene rockwool	87	85	94	94	92	73	92	89
No extra waterings	V-System	Cultilene glasswool	82	88	95	93	92	76	90	89
3x100mls @ 23,24,01h	Double Row	Grodan rockwool	80	88	93	93	93	75	92	89
3x100mls @ 23,24,01h	Double Row	Cultilene rockwool	85	87	95	94	91	78	94	90
3x100mls @23,24,01h	Double Row	Cultilene glasswool	85	86	95	93	92	70	91	88
3x100mls @ 23,24,01h	V-System	Grodan rockwool	77	90	95	94	91	79	92	90
3x100mls @ 23,24,01h	V-System	Cultilene rockwool	81	88	94	93	92	75	92	89
3x100mls @ 23,24,01h	V-System	Cultilene glasswool	82	88	95	95	92	76	91	90
3x100mls @ 08,09,10h	Double Row	Grodan rockwool	87	87	94	93	93	82	91	90
3x100mls @ 08,09,10h	Double Row	Cultilene rockwool	86	88	95	95	93	82	91	91
3x100mls @ 08,09,10h	Double Row	Cultilene glasswool	84	89	95	94	92	82	91	90
3x100mls @ 08,09,10h	V-System	Grodan rockwool	80	87	95	93	91	81	89	89
3x100mls @ 08,09,10h	V-System	Cultilene rockwool	84	85	94	93	93	82	91	90
3x100mls @ 08,09,10h	V-System	Cultilene glasswool	80	88	94	95	93	84	92	91
3x100mls @ 15,16,17h	Double Row	Grodan rockwool	84	87	94	93	93	84	90	90
3x100mls @ 15,16,17h	Double Row	Cultilene rockwool	85	88	94	93	93	74	91	89
3x100mls @ 15,16,17h	Double Row	Cultilene glasswool	83	87	95	93	93	80	92	90
3x100mls @15,16,17h	V-System	Grodan rockwool	75	88	94	93	92	80	93	90
3x100mls @ 15,16,17h	V-System	Cultilene rockwool	83	88	95	94	92	81	91	90
3x100mls @ 15,16,17h	V-System	Cultilene glasswool	83	89	94	94	93	81	88	90

APPENDIX VII

Effect of irrigation regime, growing system and substrate on percentage Class II fruit

Irrigation regime	Growing system	Substrate	Mar	Apr	May	Jun	Jul	Aug	Sep	to end Sep
No extra waterings	Double Row	Grodan rockwool	9	6	4	3	6	19	5	7
No extra waterings	Double Row	Cultilene rockwool	11	9	4	4	6	17	6	8
No extra waterings	Double Row	Cultilene glasswool	11	7	5	4	6	18	5	8
No extra waterings	V-System	Grodan rockwool	13	9	4	5	6	17	5	7
No extra waterings	V-System	Cultilene rockwool	11	11	4	4	6	19	5	8
No extra waterings	V-System	Cultilene glasswool	17	8	4	5	6	16	6	8
3x100mls @ 23,24,01h	Double Row	Grodan rockwool	18	9	5	5	5	18	6	8
3x100mls @ 23,24,01h	Double Row	Cultilene rockwool	13	9	4	4	7	15	4	7
3x100mls @23,24,01h	Double Row	Cultilene glasswool	13	9	4	5	6	20	5	8
3x100mls @ 23,24,01h	V-System	Grodan rockwool	20	7	4	4	7	13	6	7
3x100mls @ 23,24,01h	V-System	Cultilene rockwool	15	8	4	4	6	16	5	7
3x100mls @ 23,24,01h	V-System	Cultilene glasswool	15	8	4	4	6	16	6	7
3x100mls @ 08,09,10h	Double Row	Grodan rockwool	12	10	4	5	6	13	6	7
3x100mls @ 08,09,10h	Double Row	Cultilene rockwool	12	8	4	4	6	13	6	7
3x100mls @ 08,09,10h	Double Row	Cultilene glasswool	15	8	4	4	6	13	6	7
3x100mls @ 08,09,10h	V-System	Grodan rockwool	16	9	4	5	7	15	7	8
3x100mls @ 08,09,10h	V-System	Cultilene rockwool	14	10	4	4	5	14	4	7
3x100mls @ 08,09,10h	V-System	Cultilene glasswool	16	8	4	3	5	13	5	7
3x100mls @ 15,16,17h	Double Row	Grodan rockwool	13	9	5	5	5	12	6	7
3x100mls @ 15,16,17h	Double Row	Cultilene rockwool	13	9	5	4	6	17	5	8
3x100mls @ 15,16,17h	Double Row	Cultilene glasswool	14	8	4	5	5	14	5	7
3x100mls @15,16,17h	V-System	Grodan rockwool	21	10	4	5	6	13	5	8
3x100mls @ 15,16,17h	V-System	Cultilene rockwool	15	8	4	4	6	14	5	8
3x100mls @ 15,16,17h	V-System	Cultilene glasswool	16	8	4	4	5	12	5	7

APPENDIX VIII

Effect of irrigation regime, growing system and substrate on percentage waste fruit

Irrigation regime	Growing system	Substrate	Mar	Apr	May	Jun	Jul	Aug	Sep	to end Sep
No extra waterings	Double Row	Grodan rockwool	2	4	2	2	2	7	3	3
No extra waterings	Double Row	Cultilene rockwool	2	4	1	3	2	9	4	4
No extra waterings	Double Row	Cultilene glasswool	2	4	2	2	2	7	4	3
No extra waterings	V-System	Grodan rockwool	2	4	1	2	3	8	3	3
No extra waterings	V-System	Cultilene rockwool	2	4	2	2	2	7	3	3
No extra waterings	V-System	Cultilene glasswool	1	4	1	2	2	8	4	3
3x100mls @ 23,24,01h	Double Row	Grodan rockwool	2	4	2	3	2	7	3	3
3x100mls @ 23,24,01h	Double Row	Cultilene rockwool	2	4	1	2	2	7	2	3
3x100mls @23,24,01h	Double Row	Cultilene glasswool	2	4	1	2	2	9	4	3
3x100mls @ 23,24,01h	V-System	Grodan rockwool	3	3	1	2	2	8	2	3
3x100mls @ 23,24,01h	V-System	Cultilene rockwool	5	4	2	3	2	9	3	4
3x100mls @ 23,24,01h	V-System	Cultilene glasswool	3	2	1	2	2	9	3	3
3x100mls @ 08,09,10h	Double Row	Grodan rockwool	1	3	2	2	2	5	3	3
3x100mls @ 08,09,10h	Double Row	Cultilene rockwool	1	4	1	2	2	5	3	3
3x100mls @ 08,09,10h	Double Row	Cultilene glasswool	1	3	2	2	2	5	3	3
3x100mls @ 08,09,10h	V-System	Grodan rockwool	3	4	1	2	2	4	4	3
3x100mls @ 08,09,10h	V-System	Cultilene rockwool	3	5	2	3	2	4	4	3
3x100mls @ 08,09,10h	V-System	Cultilene glasswool	4	4	2	2	1	4	3	2
3x100mls @ 15,16,17h	Double Row	Grodan rockwool	2	3	1	2	2	5	4	3
3x100mls @ 15,16,17h	Double Row	Cultilene rockwool	2	3	2	3	2	8	4	3
3x100mls @ 15,16,17h	Double Row	Cultilene glasswool	3	5	2	2	2	6	3	3
3x100mls @15,16,17h	V-System	Grodan rockwool	4	3	1	2	2	7	2	3
3x100mls @ 15,16,17h	V-System	Cultilene rockwool	3	4	1	2	2	4	4	3
3x100mls @ 15,16,17h	V-System	Cultilene glasswool	2	4	1	2	2	7	6	3

APPENDIX IX

Effect of irrigation regime, growing system and substrate on percentage of Class I fruit in grade C (>57mm)

Irrigation regime	Growing system	Substrate	Mar	Apr	May	Jun	Jul	Aug	Sep	to end Sep
No extra waterings	Double Row	Grodan rockwool	3	3	17	20	17	19	13	15
No extra waterings	Double Row	Cultilene rockwool	2	2	20	21	15	18	16	15
No extra waterings	Double Row	Cultilene glasswool	3	4	19	23	17	22	18	17
No extra waterings	V-System	Grodan rockwool	2	10	28	26	19	19	18	20
No extra waterings	V-System	Cultilene rockwool	2	10	29	26	22	21	22	22
No extra waterings	V-System	Cultilene glasswool	1	6	23	22	18	21	16	18
3x100mls @ 23,24,01h	Double Row	Grodan rockwool	0	7	29	26	18	20	13	19
3x100mls @ 23,24,01h	Double Row	Cultilene rockwool	1	8	25	24	16	18	12	17
3x100mls @23,24,01h	Double Row	Cultilene glasswool	1	8	31	30	23	19	16	22
3x100mls @ 23,24,01h	V-System	Grodan rockwool	2	6	21	21	16	17	8	15
3x100mls @ 23,24,01h	V-System	Cultilene rockwool	0	6	16	19	15	17	16	15
3x100mls @ 23,24,01h	V-System	Cultilene glasswool	4	12	23	23	17	19	14	18
3x100mls @ 08,09,10h	Double Row	Grodan rockwool	2	7	22	25	18	17	19	18
3x100mls @ 08,09,10h	Double Row	Cultilene rockwool	2	7	23	20	20	20	21	19
3x100mls @ 08,09,10h	Double Row	Cultilene glasswool	1	6	21	20	17	21	20	18
3x100mls @ 08,09,10h	V-System	Grodan rockwool	1	6	26	19	15	18	18	17
3x100mls @ 08,09,10h	V-System	Cultilene rockwool	0	7	25	19	16	16	14	16
3x100mls @ 08,09,10h	V-System	Cultilene glasswool	5	6	24	19	16	12	11	15
3x100mls @ 15,16,17h	Double Row	Grodan rockwool	1	4	18	22	14	20	14	15
3x100mls @ 15,16,17h	Double Row	Cultilene rockwool	3	9	22	23	18	23	18	18
3x100mls @ 15,16,17h	Double Row	Cultilene glasswool	0	3	16	21	14	21	10	14
3x100mls @15,16,17h	V-System	Grodan rockwool	2	9	24	26	20	23	18	20
3x100mls @ 15,16,17h	V-System	Cultilene rockwool	1	9	23	27	17	20	9	18
3x100mls @ 15,16,17h	V-System	Cultilene glasswool	1	8	23	22	17	15	11	17

APPENDIX X

Effect of irrigation regime, growing system and substrate on percentage of Class I fruit in grade D (47-57mm)

Irrigation regime	Growing system	Substrate	Mar	Apr	May	Jun	Jul	Aug	Sep	to end Sep
No extra waterings	Double Row	Grodan rockwool	83	81	74	71	75	74	76	75
No extra waterings	Double Row	Cultilene rockwool	79	84	73	70	77	74	72	75
No extra waterings	Double Row	Cultilene glasswool	80	80	73	68	74	70	73	73
No extra waterings	V-System	Grodan rockwool	79	78	66	65	74	75	71	71
No extra waterings	V-System	Cultilene rockwool	76	76	65	67	72	72	68	70
No extra waterings	V-System	Cultilene glasswool	75	79	70	68	74	73	71	72
3x100mls @ 23,24,01h	Double Row	Grodan rockwool	88	82	65	66	74	70	74	72
3x100mls @ 23,24,01h	Double Row	Cultilene rockwool	81	80	69	68	75	72	75	73
3x100mls @23,24,01h	Double Row	Cultilene glasswool	82	80	62	63	71	72	72	69
3x100mls @ 23,24,01h	V-System	Grodan rockwool	79	81	72	70	74	73	75	74
3x100mls @ 23,24,01h	V-System	Cultilene rockwool	81	82	76	71	76	74	72	75
3x100mls @ 23,24,01h	V-System	Cultilene glasswool	75	74	71	69	73	71	73	72
3x100mls @ 08,09,10h	Double Row	Grodan rockwool	84	82	70	65	74	75	72	73
3x100mls @ 08,09,10h	Double Row	Cultilene rockwool	74	79	69	70	72	73	68	72
3x100mls @ 08,09,10h	Double Row	Cultilene glasswool	80	78	69	69	76	71	71	72
3x100mls @ 08,09,10h	V-System	Grodan rockwool	81	82	67	70	78	75	69	73
3x100mls @ 08,09,10h	V-System	Cultilene rockwool	75	79	67	70	76	76	75	74
3x100mls @ 08,09,10h	V-System	Cultilene glasswool	77	80	68	71	77	77	78	75
3x100mls @ 15,16,17h	Double Row	Grodan rockwool	83	82	74	69	78	72	71	75
3x100mls @ 15,16,17h	Double Row	Cultilene rockwool	84	79	71	68	74	71	71	72
3x100mls @ 15,16,17h	Double Row	Cultilene glasswool	83	81	74	69	77	72	74	74
3x100mls @15,16,17h	V-System	Grodan rockwool	83	77	70	67	72	70	68	71
3x100mls @ 15,16,17h	V-System	Cultilene rockwool	69	78	69	65	73	73	75	71
3x100mls @ 15,16,17h	V-System	Cultilene glasswool	75	79	69	70	74	76	75	73

APPENDIX XI

Effect of irrigation regime, growing system and substrate on percentage of Class I fruit in grade E (40-47mm)

Irrigation regime	Growing system	Substrate	Mar	Apr	May	Jun	Jul	Aug	Sep	to end Sep
No extra waterings	Double Row	Grodan rockwool	13	15	8	9	7	6	10	9
No extra waterings	Double Row	Cultilene rockwool	20	13	6	9	8	8	12	9
No extra waterings	Double Row	Cultilene glasswool	17	15	8	8	8	7	8	9
No extra waterings	V-System	Grodan rockwool	18	11	6	8	6	6	9	8
No extra waterings	V-System	Cultilene rockwool	21	13	6	7	6	7	8	8
No extra waterings	V-System	Cultilene glasswool	24	14	6	10	7	6	11	9
3x100mls @ 23,24,01h	Double Row	Grodan rockwool	11	10	5	7	8	10	12	8
3x100mls @ 23,24,01h	Double Row	Cultilene rockwool	17	12	6	7	9	8	12	9
3x100mls @23,24,01h	Double Row	Cultilene glasswool	17	11	6	6	7	8	10	8
3x100mls @ 23,24,01h	V-System	Grodan rockwool	18	12	7	8	9	9	16	10
3x100mls @ 23,24,01h	V-System	Cultilene rockwool	19	11	7	9	8	9	11	9
3x100mls @ 23,24,01h	V-System	Cultilene glasswool	20	13	6	8	9	9	12	10
3x100mls @ 08,09,10h	Double Row	Grodan rockwool	14	10	7	9	8	8	9	9
3x100mls @ 08,09,10h	Double Row	Cultilene rockwool	23	13	8	9	7	7	9	9
3x100mls @ 08,09,10h	Double Row	Cultilene glasswool	18	15	9	10	7	7	8	9
3x100mls @ 08,09,10h	V-System	Grodan rockwool	18	10	6	9	7	6	12	9
3x100mls @ 08,09,10h	V-System	Cultilene rockwool	24	13	7	10	7	7	10	9
3x100mls @ 08,09,10h	V-System	Cultilene glasswool	17	12	8	9	7	10	10	9
3x100mls @ 15,16,17h	Double Row	Grodan rockwool	15	13	8	8	8	7	13	10
3x100mls @ 15,16,17h	Double Row	Cultilene rockwool	13	11	7	9	8	6	10	9
3x100mls @ 15,16,17h	Double Row	Cultilene glasswool	16	15	9	9	9	7	14	11
3x100mls @15,16,17h	V-System	Grodan rockwool	15	13	6	6	6	6	12	8
3x100mls @ 15,16,17h	V-System	Cultilene rockwool	29	12	7	8	8	6	14	10
3x100mls @ 15,16,17h	V-System	Cultilene glasswool	23	13	7	8	8	8	13	9

APPENDIX XII

Effect of irrigation regimes on levels of Gold Spot

Irrigation regime	Mean Gold Spot (0 - None, 4 - Severe) Week													
	12	14	16	18	20	23	26	28	30	32	34	36	38	40
No extra waterings	0.24	0.43	0.89	1.00	1.00	0.88	2.02	1.73	1.23	1.31	1.65	2.00	1.73	0.88
3x100mls @ 23,24,01h	0.24	0.18	0.51	0.90	0.74	0.30	1.13	1.38	1.10	1.38	1.45	1.57	1.33	0.70
3x100mls @ 08,09,10h	0.20	0.40	0.83	1.23	0.93	0.75	1.60	1.02	1.06	1.17	1.28	1.71	1.65	1.29
3x100mls @ 15,16,17h	0.27	0.13	0.85	1.17	1.11	0.73	1.61	1.21	1.23	1.23	1.33	1.73	1.30	0.88
SED (3 d.f)	*0.179*	*0.111*	*0.339*	*0.273*	*0.338*	*0.271*	*0.669*	*0.326*	*0.459*	*0.187*	*0.482*	*0.383*	*0.375*	*0.362*
LSD (5%)	*0.421*	*0.261*	*0.798*	*0.642*	*0.795*	*0.638*	*1.574*	*0.767*	*1.080*	*0.440*	*1.134*	*0.901*	*0.882*	*0.852*
Significance	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*

APPENDIX XIII

Effect of irrigation regimes on the percentage soluble solids content of fruit

Irrigation regime	Week													
	12	14	16	18	20	23	26	28	30	32	34	36	38	40
No extra waterings	3.92	4.21	4.30	4.74	4.72	5.00	4.95	4.83	4.71	4.75	4.74	4.68	4.90	4.52
3x100mls @ 23,24,01h	3.87	4.13	4.24	4.58	4.64	4.86	4.97	4.80	4.62	4.61	4.64	4.68	4.92	4.60
3x100mls @ 08,09,10h	3.81	4.08	4.30	4.55	4.60	4.65	4.85	4.82	4.72	4.75	4.65	4.75	4.86	4.50
3x100mls @ 15,16,17h	3.90	4.12	4.31	4.63	4.63	4.77	4.82	4.82	4.68	4.79	4.64	4.80	4.91	4.63
SED (3 d.f)	*0.069*	*0.127*	*0.079*	*0.083*	*0.067*	*0.125*	*0.072*	*0.025*	*0.048*	*0.068*	*0.042*	*0.104*	*0.113*	*0.121*
LSD (5%)	*0.162*	*0.299*	*0.186*	*0.195*	*0.158*	*0.294*	*1.169*	*0.059*	*1.113*	*0.160*	*1.099*	*0.225*	*0.266*	*0.285*
Significance	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*

APPENDIX XIV

Effect of irrigation regimes on the percentage dry matter content of fruit

Irrigation regime	Week													
	12	**14**	**16**	**18**	**20**	**23**	**26**	**28**	**30**	**32**	**34**	**36**	**38**	**40**
No extra waterings	5.28	5.28	5.28	5.74	5.90	6.23	6.19	6.06	6.18	6.22	6.16	6.01	5.86	--
3x100mls @ 23,24,01h	5.18	5.10	5.07	5.48	5.83	6.09	6.11	6.06	6.10	6.05	6.04	5.98	5.76	--
3x100mls @ 08,09,10h	4.93	5.09	5.18	5.50	5.73	5.99	6.06	6.09	6.19	6.15	6.18	6.09	5.77	--
3x100mls @ 15,16,17h	5.30	5.19	5.20	5.57	5.78	6.04	6.00	6.07	6.26	6.11	6.11	6.06	5.84	--
***SED* (3 d.f)**	*0.117*	*0.091*	*0.075*	*0.039*	*0.119*	*0.059*	*0.130*	*0.081*	*0.108*	*0.053*	*0.089*	*0.165*	*0.092*	--
***LSD* (5%)**	*0.275*	*0.214*	*0.176*	*0.092*	*0.280*	*0.139*	*0.306*	*0.191*	*0.254*	*0.125*	*0.209*	*0.388*	*0.216*	--
Significance	*N.S.*	*N.S.*	*N.S.*	*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*	--

APPENDIX XV
Terms and Conditions

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

1. TITLE OF PROJECT

Contract No: PC82
(Shortened contract)
Contract date: 14.9.93

IRRIGATION REGIMES FOR TOMATOES GROWN ON ROCKWOOL

2. BACKGROUND AND COMMERCIAL OBJECTIVE

As for PC/82.

3. POTENTIAL FINANCIAL BENEFIT TO THE INDUSTRY

As for PC/82.

4. SCIENTIFIC/TECHNICAL TARGET OF THE WORK

As for PC/82.

5. CLOSELY RELATED WORK - COMPLETED OR IN PROGRESS

As for PC/82.

6. DESCRIPTION OF THE WORK

As for PC/82.

Availability of results

Interim results will be made available to the HDC and visiting groups throughout the season. A full report will be completed on behalf of the HDC at the end of 1993.

7. COMMENCEMENT DATE, DURATION AND REPORTING

Start date 01.11.93; duration 1 year. The final report for the project will be completed by 01.01.94.

8. STAFF RESPONSIBILITIES

As for PC/82.

9. LOCATION

As for PC/82.

Contract No: PC82
(Shortened Contract)

TERMS AND CONDITIONS

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 CHIEF EXECUTIVE

Date 15.9.93

Contract No: PC82
(Shortened Contract)

TERMS AND CONDITIONS

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 CHIEF EXECUTIVE

Date 15.9.93