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ANNUAL CONTRACT REPORT

Tomatoes: Irrigation regimes for a long season rockwool crop

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1991/92 (year one)

Annual Report June 1993
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Tomatoes: Irrigation regimes for a long season rockwool crop

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AUTHENTICATION

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

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ACKNOWLEDGEMENTS

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SUMMARY

Work done at HRI Efford during the 1991-1992 cropping season 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 effects of these regimes on yield, fruit quality and shelf-life characteristics were measured.

A long season tomato crop (*Lycopersicon esculentum Mill*) cvs Liberto and Spectra was sown on the 7 November 1991. Propagation and subsequent early growth was standard throughout and followed current commercial practice. Irrigation regimes commenced during week six.

Irrigation frequency/volume by day of 50, 100, 200 or 400 mls per application (same total volume dawn-dusk) had no significant effect on yield or the percentage Class 1 fruit. However, where extreme treatments (50 mls and 400 mls) were combined with no night watering, fruit quality and shelf-life were generally reduced.

Increase in fruit size as a result of the application of night irrigation was attributed to the increase in total volume over 24h rather than a result of night irrigation *per se*.

Surprisingly, percentage drainage from the V-system was reduced in comparison to that recorded from the Double Row treatments at Efford, suggesting reductions in nutrient emission to the environment. As this is the first year's trial in a two year programme, these latter results should be interpreted with caution pending results from year two.

INTRODUCTION

The irrigation requirement of glasshouse crops is at present calculated largely on the amount of solar radiation incident on the canopy. Although theoretical watering figures for soil grown crops have been available for many years, the introduction of rockwool systems has meant that growers have had to develop new watering strategies to compensate for the reduced root volume and water holding capacity of the substrate. These advances have necessitated the development of increasingly sophisticated irrigation computers which in turn have increased the number of control strategies available to the user. In the first year of this study an attempt was made to optimise both irrigation frequency and volume by day, in addition to quantifying the perceived benefits of night watering. Their effects on yield and fruit quality was determined.

Optimisation of irrigation frequency and volume may also serve to reduce the percentage run off with concomitant savings in both water and nutrients. Assuming an NO_3-N concentration of 150 mg/litre in the drainage, recent calculations (Dr Mike Marks, ADAS-Wye) would suggest that reducing the run off from 40-30 per cent would reduce Nitrate-N loss from 700 to 450 kg/ha (based on a crop water **requirement** of 7 million litres/ha per season). The reader is referred to the report for project PC 55 "Tomatoes: An assessment of Nitrate and Chloride salts of Potassium and Calcium, their effects on yield and fruit quality".

OBJECTIVES

The commercial objectives of this study were several fold. Firstly, to attempt to optimize irrigation for a rockwool tomato crop by manipulation of the irrigation frequency and volume per round. Secondly, to quantify the possible benefits of night watering. Both 'day' and 'night' regimes were evaluated by their ability to influence yield and fruit quality. Measurement of the applied irrigation and percentage run off on a daily basis in addition to slab conductivity readings aimed to evaluate the effect of these regimes on the root zone. With this final objective in mind the 'V'-system was compared with the standard double row.

MATERIALS AND METHODS

Site details

The trial was done at HRI Efford utilising two thirds of the F-Block facility. The layout of the trial is illustrated in Appendix I, Page 41.

Treatments

The main treatments aimed to examine irrigation frequency in relation to the total volume applied. A figure of c. 120% of the calculated daily requirement (based on light integral) was used as the base value thus allowing for 20% run off. The irrigation system was configured such that the same total volume/plant was applied over the 'day' (dawn-dusk) but at different frequencies and hence volumes per irrigation round. These were:

A. 50 mls per round
B. 100 mls per round
C. 200 mls per round
D. 400 mls per round

Therefore, for every 'pulse' on the light integrator the 50 ml treatment received a watering; the 400 ml regime being watered on the eighth. The light integral required to deliver a 'pulse' was adjusted weekly and based on the long term average light integral for that week. On a given day, where the actual light integral did not result in a watering ratio of 8:4:2:1 (50:100:200:400 mls), ie only 7 pulses had been accumulated at dusk, a 'manual' pulse was given to balance the treatments. If however, a 9th was accumulated the system was left (refer to the discussion). Irrigation treatments commenced in week six.

Sub treatments

Each experimental compartment (refer to trial plan, Appendix I, page 41) comprised three double rows of 40 plants with two single guard rows. A single sub-treatment was applied to each double row.

1. No night watering
2. 3 x 100 ml night waterings
3. 'V'-system with 50% rockwool utilisation (also received night watering as in 2).

Both 'main' and 'sub' treatments were applied to cvs Liberto and Spectra.

Cultural techniques

Seeds of tomato (*Lycopersicon esculentum Mill*) cvs Liberto and Spectra were sown on 7 November 1991, in rockwool multiblocks (40 x 40 x 40 mm) which had been wetted up the day before using feed solution with a pH of 5.0 and an EC of 1500 μS. Following germination the EC was raised to 2500 μS coincident with expansion of the cotyledons. Prior to blocking on, eleven days after sowing, the 0.65 litre rockwool blocks were wetted up with feed at pH 5.0 and an EC of 2500 μS, the aim being to achieve a stable block pH of c.6.0.

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

Modified 'Blueprint' temperatures were applied throughout propagation.

The 'Blueprint regime'

Stage	Target Air temperatures°C		
	Day	Night	Vent
0. Sowing to Germination (4 days)	24	24	26
1. Germination to blocking on	20	20	24
2. Blocking on until 1st visible bud	20	16	24

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

Following slab contact plants were strung to a 3 metre crop wire and layered on reaching wire height. In all respects crop management followed best commercial practice.

Pest and disease control

A number of beneficial insects were routinely introduced to combat the major tomato pests.

Predator	Introduction frequency	Prey
Encarsia formosa	Weekly	Whitefly
Dacnusa spp.	Weekly	Leaf Miner
Aphidius spp.	Weekly	Aphids

Fungicides were restricted to a minimum in line with current commercial practice; those applied are listed in Appendix II, page 42, along with a full crop diary.

Assessments

The following records were taken throughout the course of the study.

- Date of first anthesis, first fruit pick, number of fruit set and the number of marketable fruit on trusses 1-7 for four plants per plot.
- Graded and total marketable yield, percentage Class 1 fruit.
- Assessment of tomato fruit quality; including physical fruit appearance, shelf life studies and fruit sugar and acid levels.
- Monitoring of applied irrigation and run off.
- Daily monitoring of root zone pH and conductivity for all nutrient regimes.
- Routine analyses of applied feed and slab solution for nutritional content.
- Monthly analyses of leaf and fruit tissue for mineral content.
- Full monitoring of the glasshouse aerial environment.
- Additional assessments as required, eg. the incidence of Blossom End Rot.

Experimental design and explanation of statistical terms.

Each main treatment was replicated twice (refer to trial plan, Appendix I, page 41). A balanced design enabled the experimental data to be subjected to a full analysis of variance and hence assign statistical significance to any treatment differences.

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 any two figures within a given column that is required for those figures to be statistically different.

N.S. = Not significant.

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

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

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

Fruit Quality and Shelf Life Assessments

Tomatoes were sampled from those picked for sale prior to grading. Samples were taken in weeks 13, 15, 19, 23, 27, 31 and 35.

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)
Radial Cracking
Gold Spot (calyx end)
Gold Marbling (flecking - blossom end)
Blotchy Ripening
Red Noses

Disorders were scored from 0 (none present) to 4 (severe) for the 10 fruit, from which a mean was calculated for each plot.

Shelf Life Assessments and Chemical Analysis

Tomatoes were selected that fulfilled the following criteria.

Class 1 fruit
ATB Colour stage 4
Size D

Normally 10 fruit were selected. However, when picks were small or when fruit did not fulfil the above criteria, fewer were selected or Size C or E fruit included.

Tomatoes were passed through a handling simulator (500-600 mm 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 end of the 6 day 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 conductivity, 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 a 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.

Conductivity μS: Measurements of the electrical conductivity of the juice were made using a hand held probe.

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

RESULTS

Flowering and fruit set

The time taken to 1st anthesis, 1st fruit pick, along with the number of fruit set and the number of marketable fruit on the first seven trusses were unaffected by the irrigation regimes or their sub treatments. These data are presented in Appendix III, pages 43 to 46.

Yield, gradeout and monetary returns

To the end of May there was no significant effect of irrigation frequency by day on the total yield of fruit. However, the effect of the sub-treatments was highly significant ($P < 0.001$, Table 1 page 13). The highest yield of 15.12 kgm^{-2} was recorded from the double row with night waterings (+ NW). Over the same period the double row without night waterings (-NW) yielded 1.59 kgm^{-2} less. At 14.06 kgm^{-2} the V-system was intermediate. The same trend was evident to the end of the season ($P < 0.001$, Table 2 page 14) with 50.63, 47.70 and 47.16 kg for the double rows (+NW), (-NW) and V-system respectively. Liberto (49.93 kgm^{-2}) out yielded Spectra (47.06 kgm^{-2}) by 2.87 kgm^{-2} to the 2 October.

Although not significant within the context of this study, there was a strong trend suggesting that low volume applications (50 mls/round) combined with no night waterings were detrimental to fruit quality (% Class 1 fruit) in the early part of the season.

Cumulative % Class 1 fruit (end of May)

mls/round by day	Double row (-NW)	Double row (+NW)	V-system (+NW)
50	65	82	80
100	85	85	83
200	78	83	80
400	85	83	83

This trend was less apparent when considering results to the end of the season.

As with yield, gradeout was not affected by the day regimes but to the end of May those sub-treatments receiving night waterings, both double row and V-system, produced a higher proportion of C grade fruit ($P < 0.01$, Table 1 page 13). Consequently, the number of E's were lowest where night waterings had been applied. Varietal differences were significant at the end of September with Spectra producing the larger fruit.

Reflecting yield and gradeout results, monetary returns ($£m^{-2}$) were significantly influenced by the sub-treatments during the early portion of the season ($P < 0.01$). At £10.90 m^{-2} the double row (+NW) accrued the highest returns; the double row (-NW) the lowest (Table 1). Monetary returns were not significantly different to the end of the season. A full analysis of monthly data can be found in Appendix IV, pages 47 to 51.

Table 1

Effect of irrigation regime and variety on total yield (kg/m^{-2}), gradeout and crop monetary return ($£m^{-2}$) to the end of May

Day regime mls/round	kg/m^{-2}	% Class 1	% C's 57-64mm	% D's 47-57mm	% E's 40-47mm	$£m^{-2}$
50	13.73	76	12	69	18	9.48
100	14.20	84	12	71	16	10.24
200	13.78	81	11	73	15	9.84
400	15.23	84	16	72	11	10.98
SED (d.f=3)	*1.217*	*4.9*	*4.9*	*2.0*	*6.8*	*1.016*
LSD 5%	*3.872*	*15.6*	*15.6*	*6.4*	*21.6*	*3.232*
Significance	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
Night regime or 'V'-system						
None	13.53	78	8	71	20	9.53
3 x 100mls	15.12	83	16	71	12	10.90
V-system	14.06	82	15	72	13	9.98
SED (d.f=8)	*0.274*	*2.5*	*1.7*	*1.7*	*1.9*	*0.243*
LSD 5%	*0.632*	*5.7*	*3.9*	*3.9*	*4.4*	*0.560*
Significance	***	*NS*	**	*NS*	**	**
Variety						
Liberto	14.66	81	13	72	15	10.58
Spectra	13.81	81	12	71	16	9.69
SED (d.f=3)	*0.106*	*0.8*	*1.0*	*1.0*	*1.3*	*0.147*
LSD 5%	*0.337*	*2.5*	*3.2*	*3.2*	*4.1*	*0.467*
Significance	**	*NS*	*NS*	*NS*	*NS*	**

Table 2

Effect of irrigation regime and variety on total yield (kg/m^{-2}), gradeout and crop monetary return (£m^{-2}) to the end of September

Day regime mls/round	kg/m^{-2}	% Class 1	% C's 57-64mm	% D's 47-57mm	% E's 40-47mm	£m^{-2}
50	48.52	83	23	66	9	51.06
100	47.82	84	17	71	10	51.91
200	48.88	84	25	66	9	47.77
400	48.76	80	20	70	8	48.44
SED (d.f=3)	*1.058*	*1.4*	*1.1*	*1.9*	*0.5*	*5.335*
LSD 5%	*3.366*	*4.4*	*3.5*	*6.0*	*1.6*	*16.975*
Significance	*NS*	*NS*	*	*NS*	*NS*	*NS*
Night regime or 'V'-system						
None	47.16	80	19	69	9	49.48
3 x 100mls	50.63	84	23	67	9	51.07
V-system	47.70	84	21	69	9	48.84
SED (d.f=8)	*0.596*	*1.5*	*1.7*	*1.4*	*1.1*	*2.600*
LSD 5%	*1.374*	*3.4*	*3.9*	*3.2*	*2.5*	*5.995*
Significance	***	*	*NS*	*NS*	*NS*	*NS*
Variety						
Liberto	49.93	81	18	71	10	52.69
Spectra	47.06	84	24	66	8	46.90
SED (d.f=3)	*0.632*	*1.1*	*0.4*	*0.5*	*0.4*	*1.998*
LSD 5%	*2.010*	*3.5*	*1.3*	*1.6*	*1.3*	*6.357*
Significance	*	*NS*	***	***	*NS*	*NS*

Fruit Quality

Disorder assessments

The full results from the disorder assessments are tabulated as treatment means in Appendix V, pages 52 to 58.

Boxiness: Levels of this disorder were generally low throughout the season. Whilst there were no significant treatment effects, levels of boxiness were consistently higher for the V-system until week 23 (Figure 1, page 17). There was some evidence that the V-system had less of an effect on Spectra than on Liberto, this was most apparent in week 31 when there was a significant interaction between variety and the sub-treatments ($P < 0.01$; Figure 2 page 18).

Slab-sidedness: Moderate levels of this disorder were recorded at the beginning and end of the season, with Liberto recording higher levels than Spectra in most weeks and significantly higher levels in weeks 23 and 31 ($P < 0.05$). There were no significant effects of the day regimes, however, higher levels were frequently associated with the V-system, but not consistently so.

Ribbing: Very low levels of this disorder were recorded throughout the trial and no differences between treatments or varieties were found.

Nippling: This disorder was also recorded only at very low levels. Although not consistent throughout the trial, in weeks 13 and 31 the no night watering treatment showed significantly higher levels than the other sub-treatments ($P < 0.05$).

Radial Cracking: Levels in the latter part of the season were higher for the no night watering treatment (Figure 3, page 19) and significantly so in week 35 ($P < 0.05$). The highest levels of radial cracking were generally found where the no night watering treatment was combined with the 400 ml 'day' regime (Figure 4, page 20).

Netting: Although not significant within the context of this study, the trends for netting were similar to those for radial cracking. The highest levels were recorded where plants were subjected to a regime of 400 mls/round by day with no night waterings (Figure 5, page 21).

Gold Spot: High levels of this disorder were recorded, particularly at the end of the season. Liberto had higher levels of gold spot than Spectra in most weeks and significantly higher in week 31. There were no significant or consistent differences between treatments.

Gold Marbling: In week 13 significantly higher levels of gold marbling were recorded for the no night watering treatment, but this result was not repeated consistently through the season. There was some evidence that fruit from the V-system had lower levels of gold marbling than the standard double row and no night watering treatment, although again these trends were not significant.

Blotchy Ripening: Moderate levels of this disorder were recorded from week 23 onwards. The variety Spectra had consistently higher levels of blotchy ripening than Liberto, significantly higher in week 31 ($P < 0.05$). There were no significant or consistent differences when comparing treatments.

Figure 1. Effect of sub-treatments on the incidence of Boxiness.

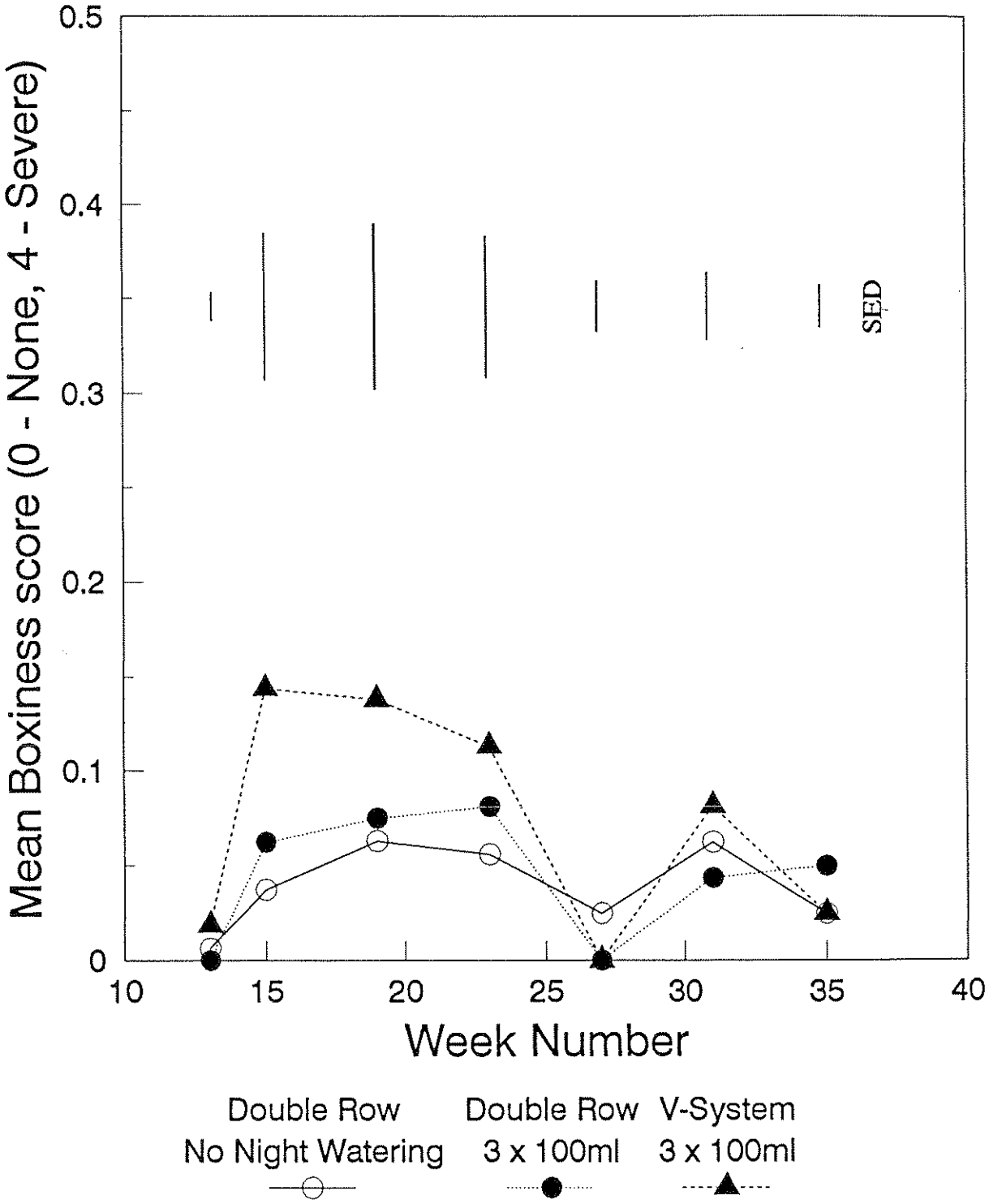


Figure 2. Interaction of sub-treatment and variety on the level of Boxiness in week 31.

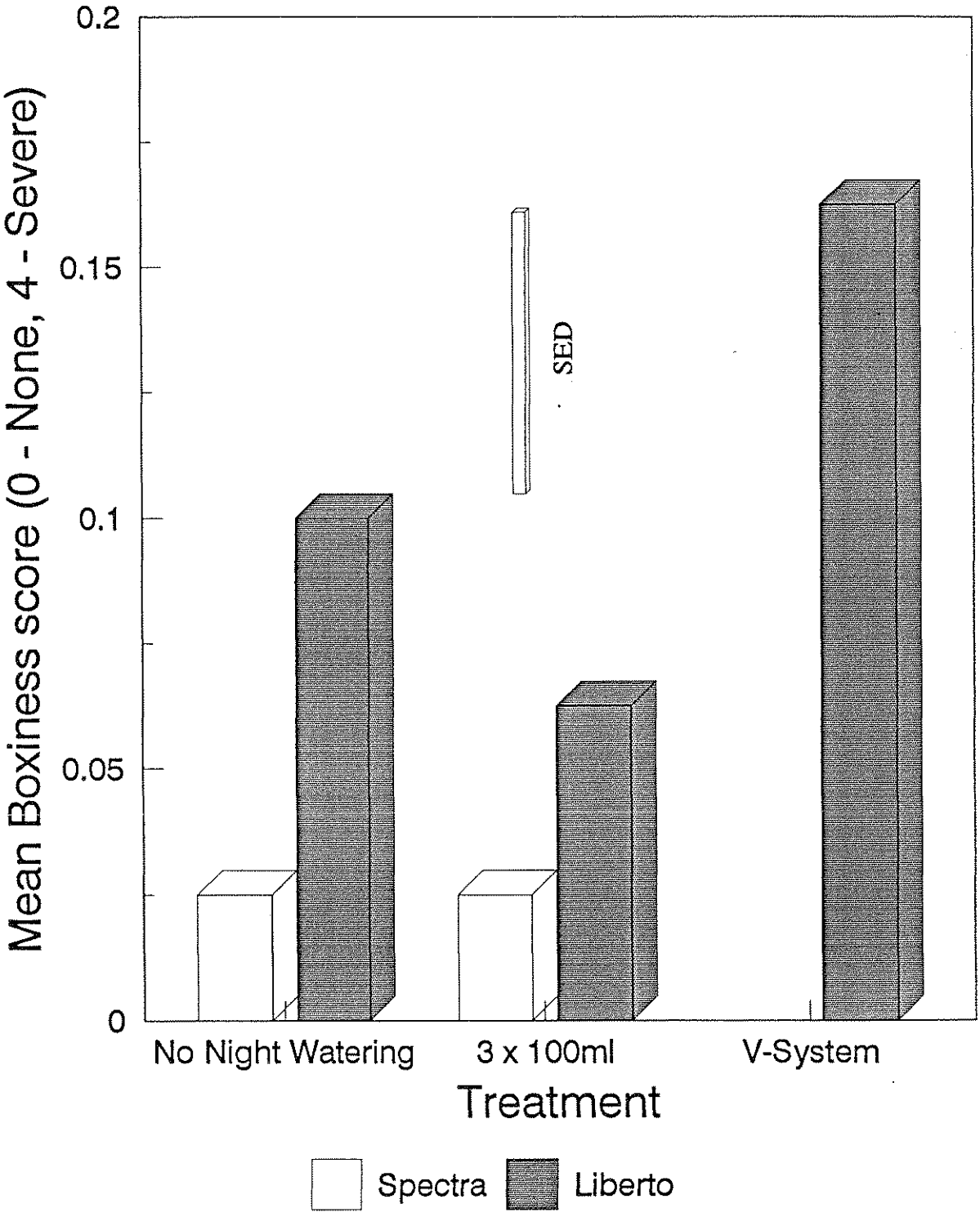


Figure 3. Effect of sub-treatments on the incidence of Radial Cracking.

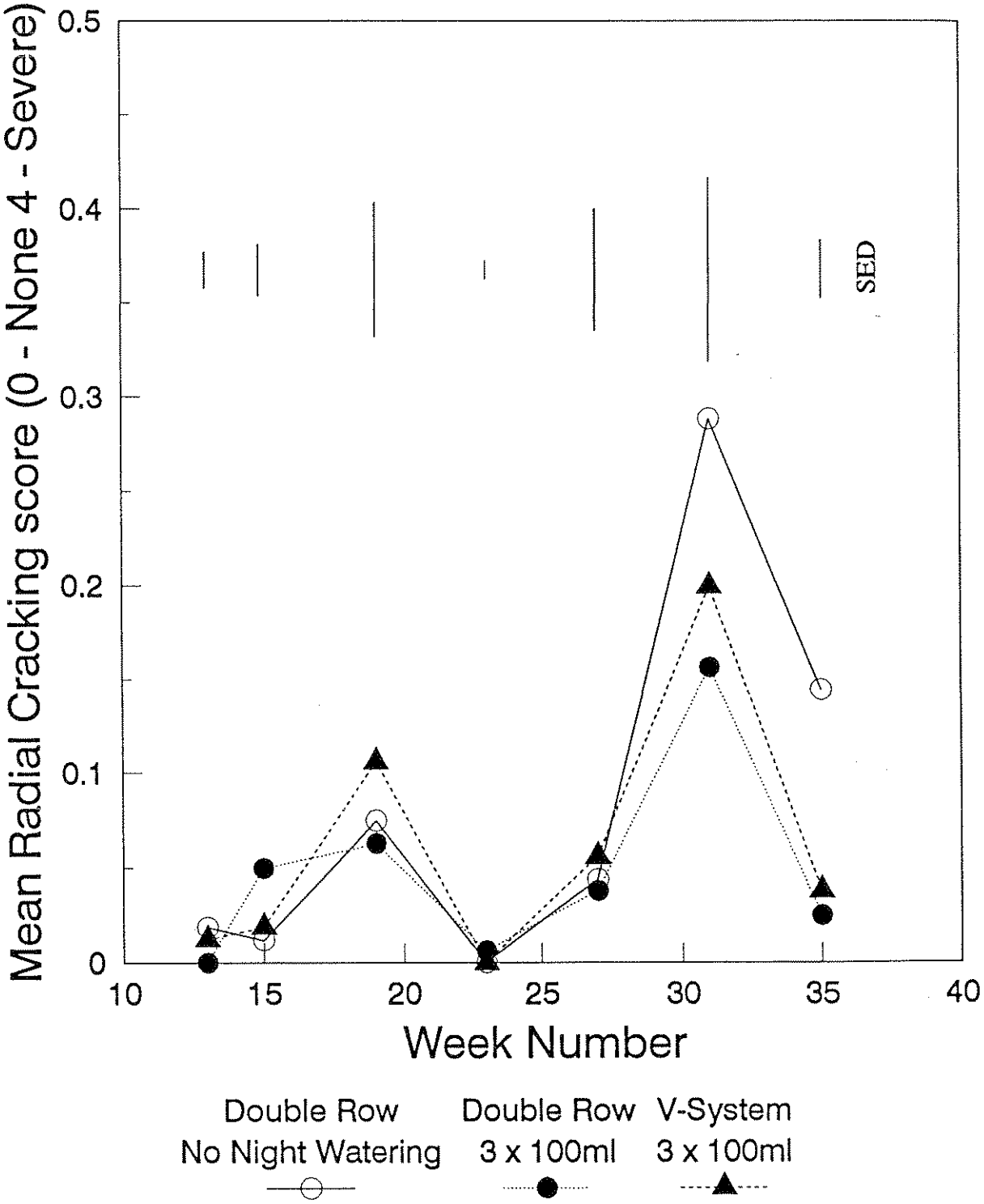


Figure 4. Effect of no night watering in combination with 'day' regimes on the severity of Radial Cracking.

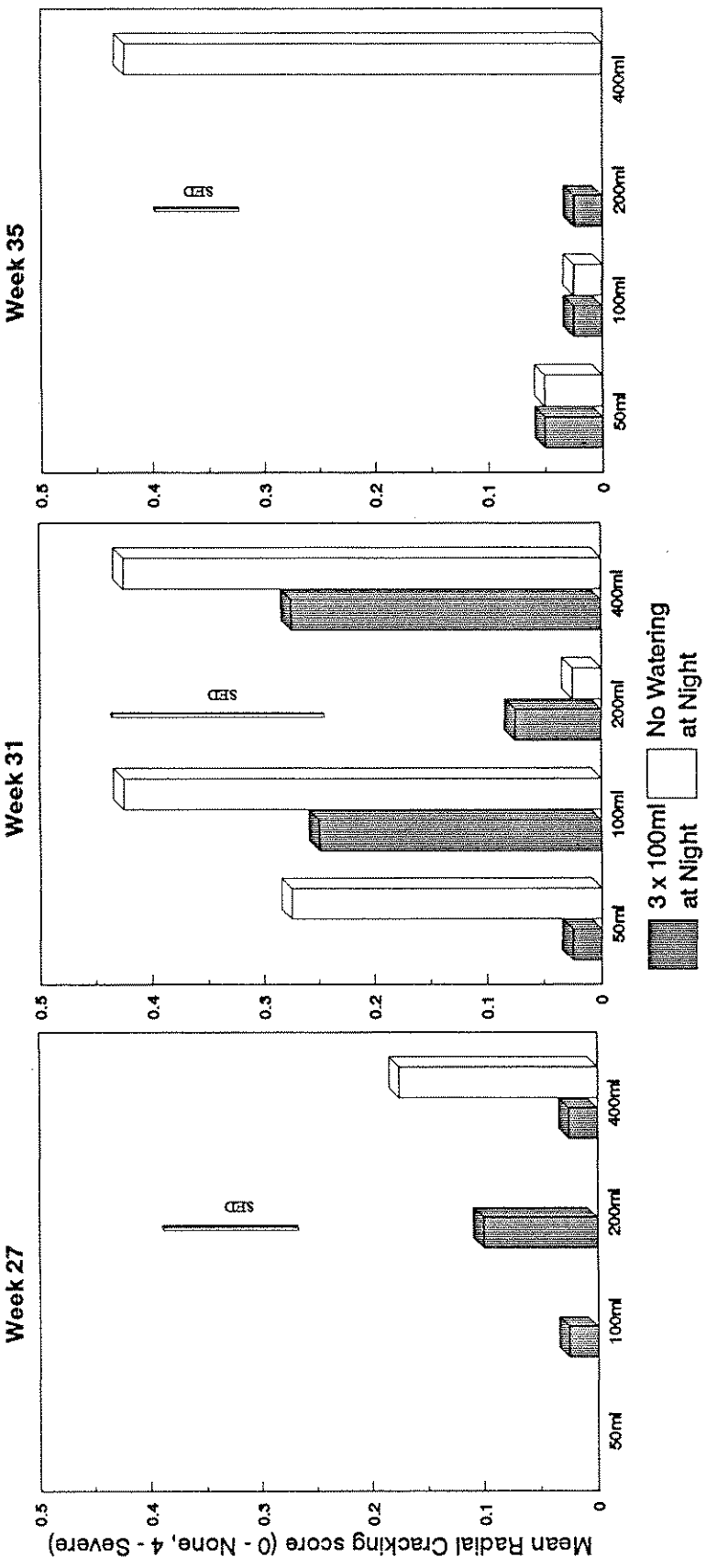
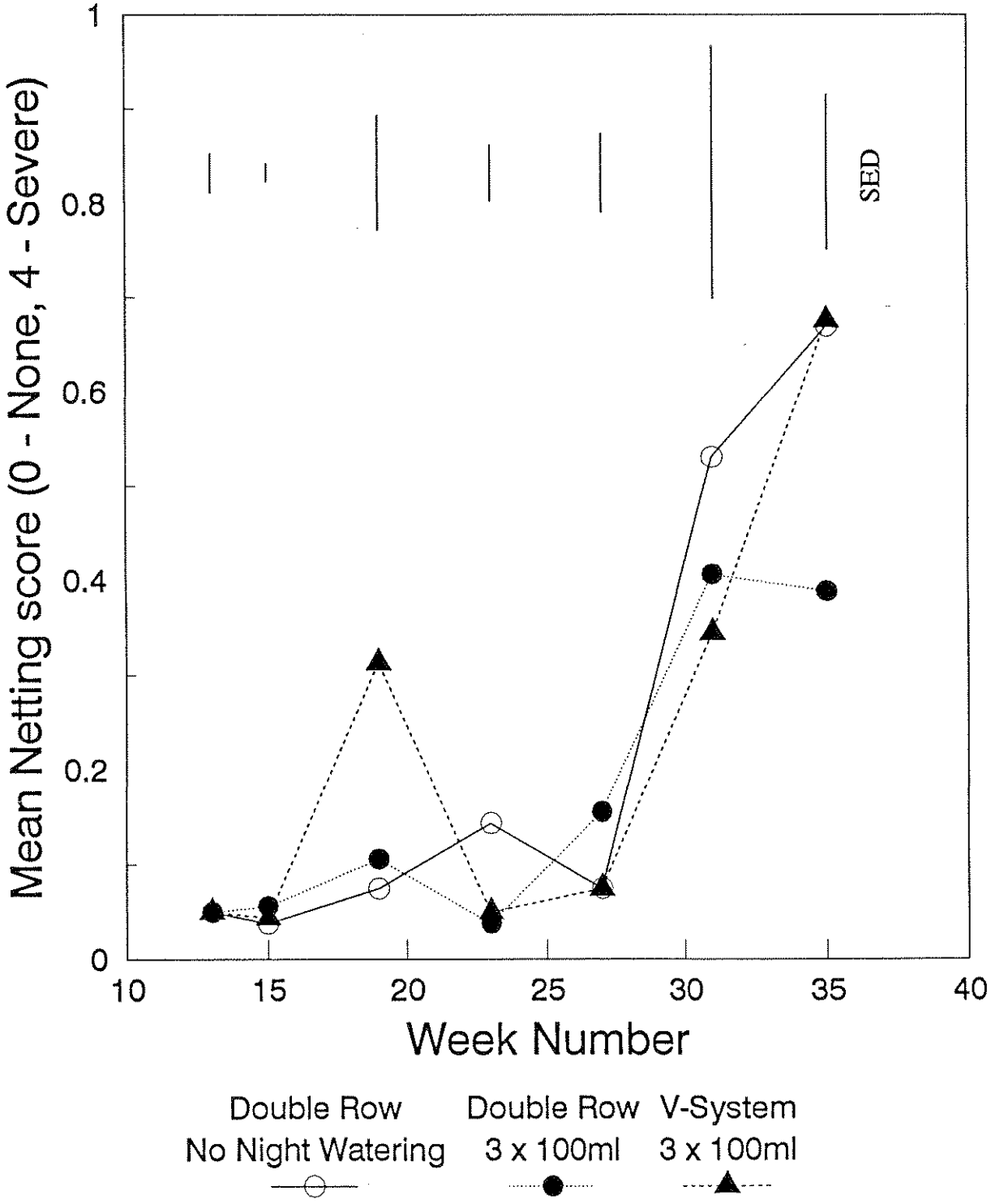


Figure 5. Effect of sub-treatments on the incidence of Netting.



Shelf-Life and Internal Composition

The results of shelf-life assessments and fruit internal composition determinations are tabulated in Appendix VI, pages 59 to 65.

Compression: There were no significant differences between treatments. Soft fruit was common from the 50 ml day watering regime. However, the highest compression readings were from the no night watering treatments when combined with the 400 ml day watering regime towards the end of the season.

Weight Loss During Shelf-Life: Very high % weight loss figures were recorded towards the end of the season for all varieties and treatments. Spectra recorded higher % weight loss than Liberto for every assessment; significantly higher in weeks 27, 31 and 35 ($P < 0.05$).

Up until week 19 the no night watering treatment produced fruit with the lowest % weight loss during shelf-life (Figure 6, page 24), significantly lower than both the standard double row and the V-system in weeks 15 and 19. However, from week 23 onwards the no night watering treatment produced fruit with the highest weight loss figures, significantly higher than both the standard double row and the V-system in week 35.

In weeks 31 and 35 very high % weight loss occurred where the no night watering treatment was combined with the 400 ml day watering regime.

Endpoint pH: pH increased as the season progressed indicating decreasing fruit acidity. Liberto had higher pH than Spectra in every assessment and significantly higher from week 23 onwards.

There were no significant differences between day watering regimes. However, the 50 ml and 200 ml regimes had a lower pH up until week 19 and higher pH thereafter than the 100 ml and 400 ml treatments (Figure 7, page 25).

Consistently higher pH values were found for the standard double row than the V-system and no night watering treatments; significantly higher in week 15 ($P < 0.05$, Figure 8 page 26).

Soluble Solids Content: Overall there were few significant or consistent effects when comparing treatments. However, from week 23 onwards there was a trend which recorded the highest soluble solids content from the 400 ml/round treatment (Figure 9, page 27). In week 31 both the 400 and 100 ml treatments produced significantly higher soluble solids content than either the 50 or 200 ml regimes. The soluble solids content of fruit from the no night watering treatment was higher than that of fruit from the other treatments in every assessment (Figure 10, page 28) and significantly higher in week 15. From week 23 onwards the highest soluble solids figures were from the no night watering treatment where it was combined with the 400 ml day watering regime.

Dry Matter Content: Differences between day watering regimes were not significant. However, up to and including to week 19 the 50 ml and 200 ml regimes produced fruit with high dry matter content, but from week 23 onwards they produced fruit low in dry matter when compared to the 400 ml and 100 ml regimes (Figure 11, page 29).

The no night watering treatment consistently resulted in higher dry matter content and significantly higher in weeks 15 and 19 ($P < 0.05$, Figure 12, page 30). From week 23 onwards the highest percentage dry matter figures resulted from the combination of the no night watering treatment and the 400 ml day watering regime.

Figure 6. Effect of sub-treatments on Percentage Weight Loss after 6 days of shelf-life.

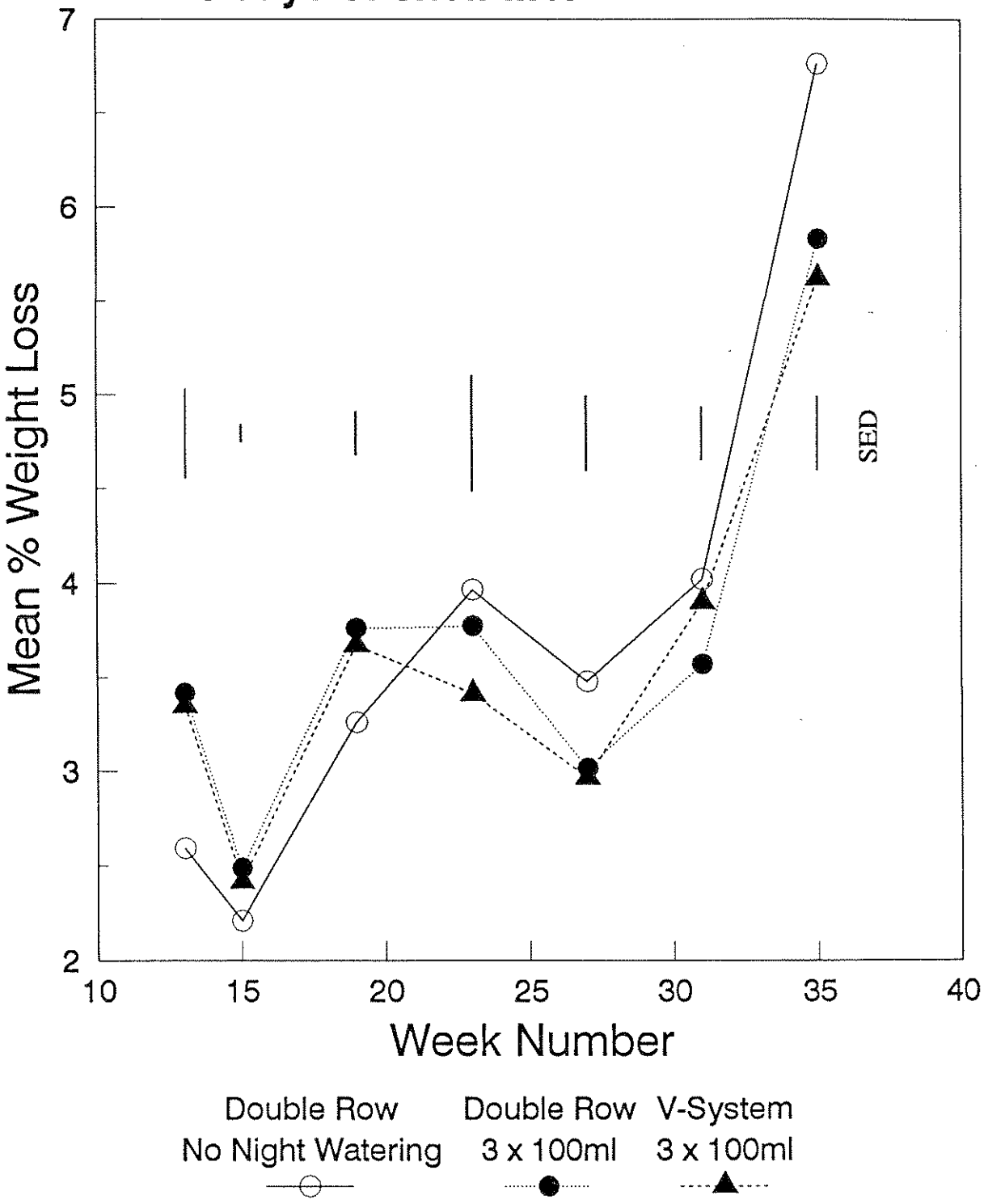


Figure 7. Effect of irrigation regimes on fruit acidity.

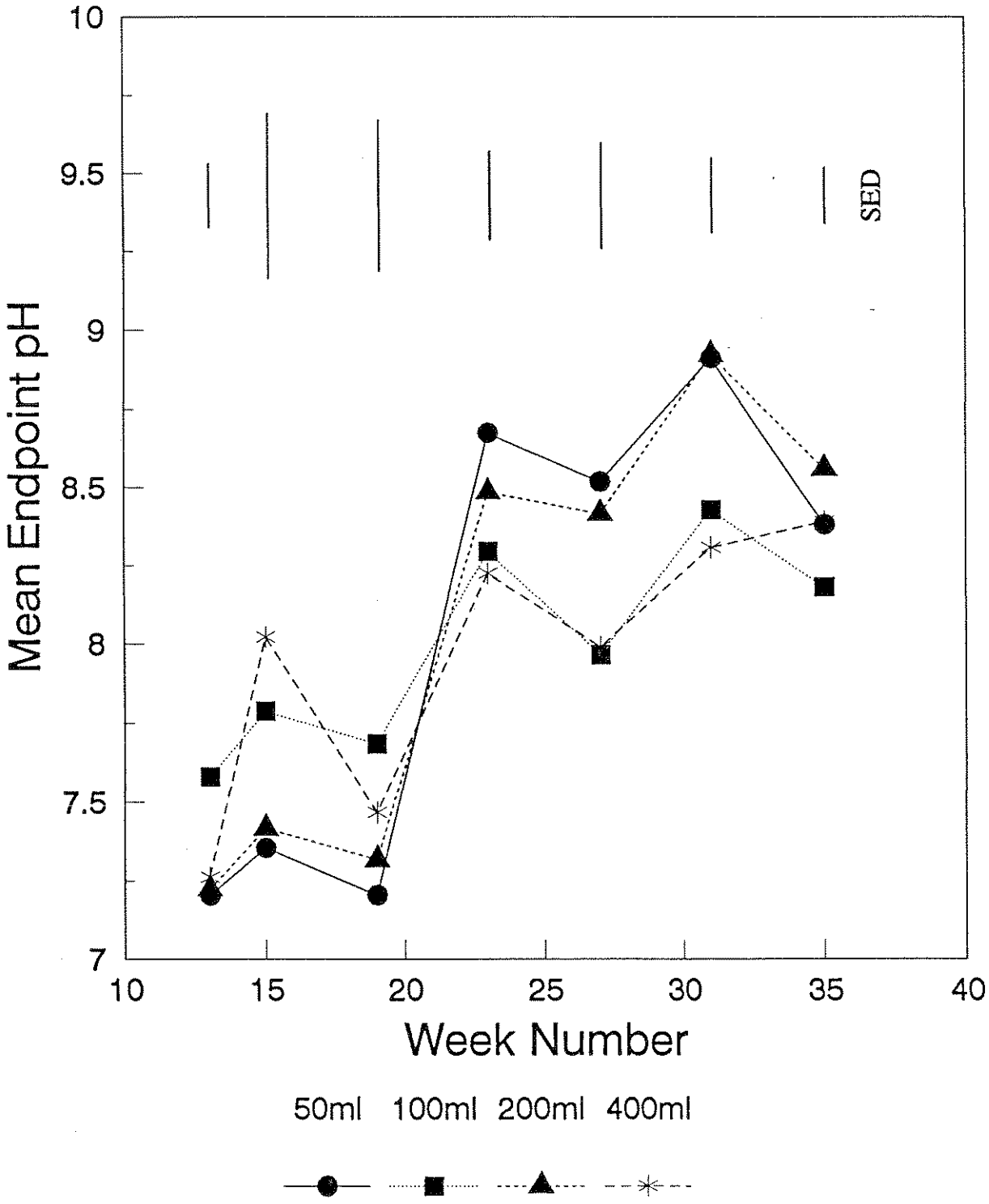


Figure 8. Effect of sub-treatments on fruit acidity.

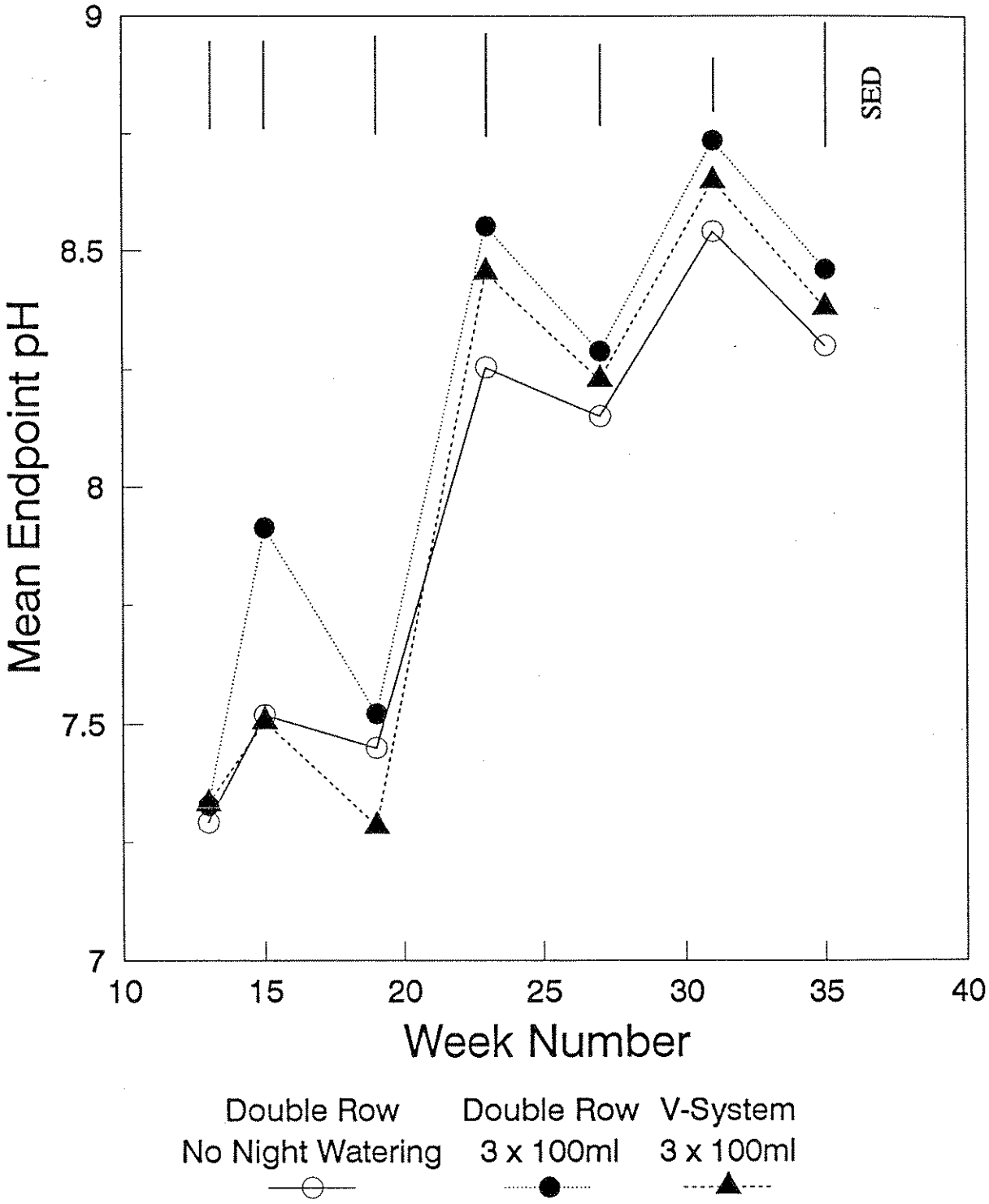


Figure 9. Effect of irrigation regimes on the level of Soluble Solids in fruit.

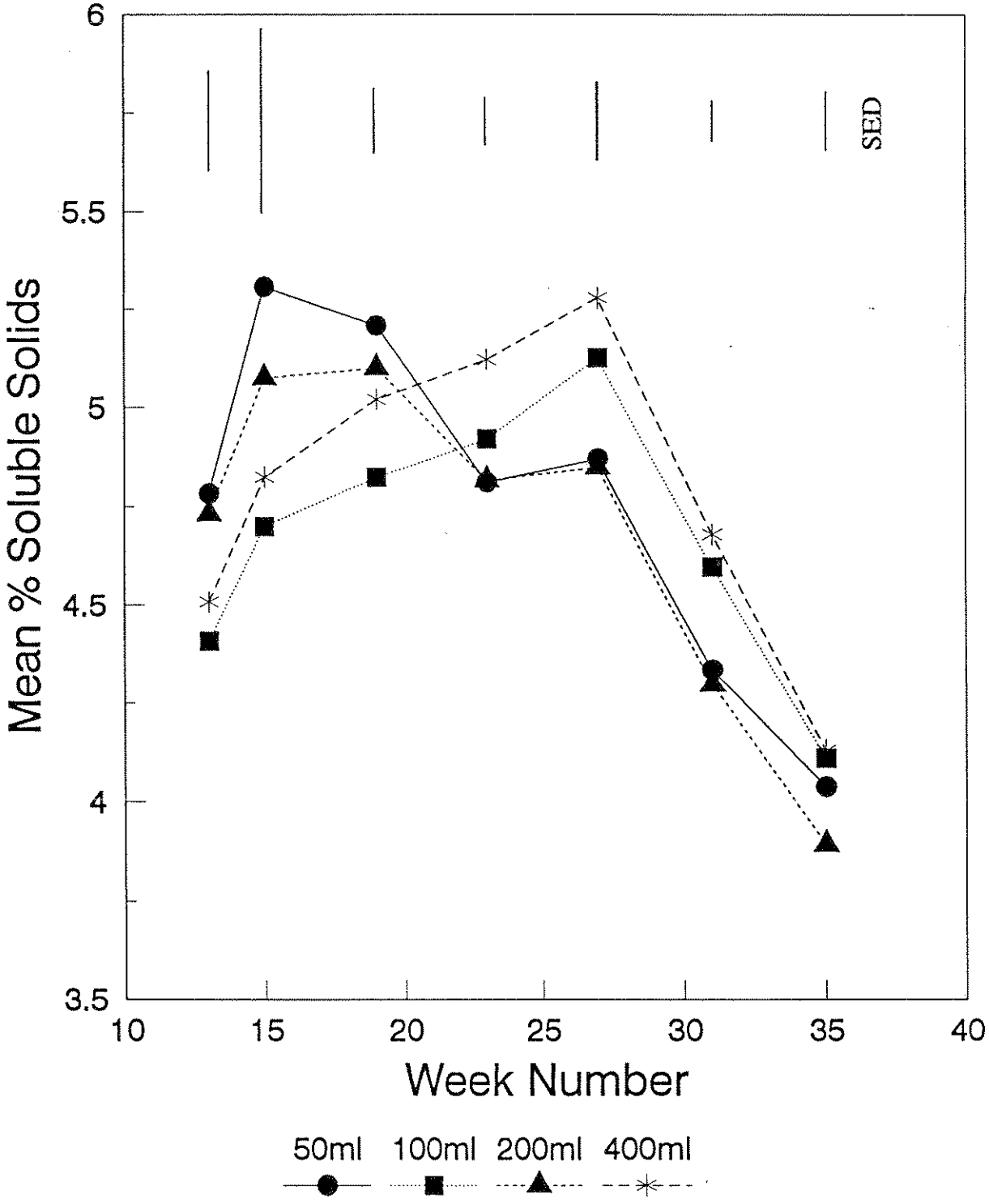


Figure 10. Effect of sub-treatments on the level of Soluble Solids in fruit.

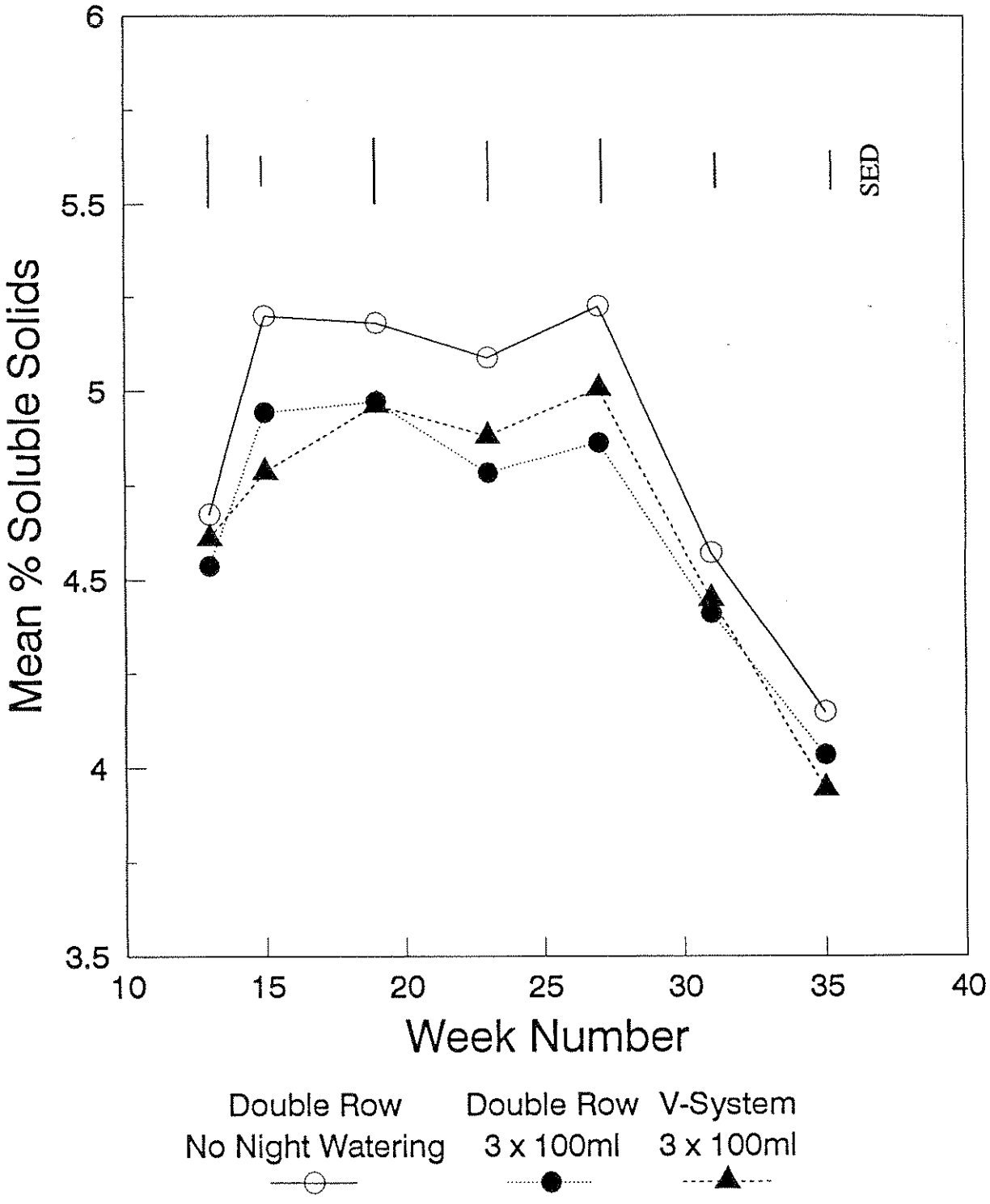


Figure 11. Effect of irrigation regimes on Percentage Dry Matter in fruit.

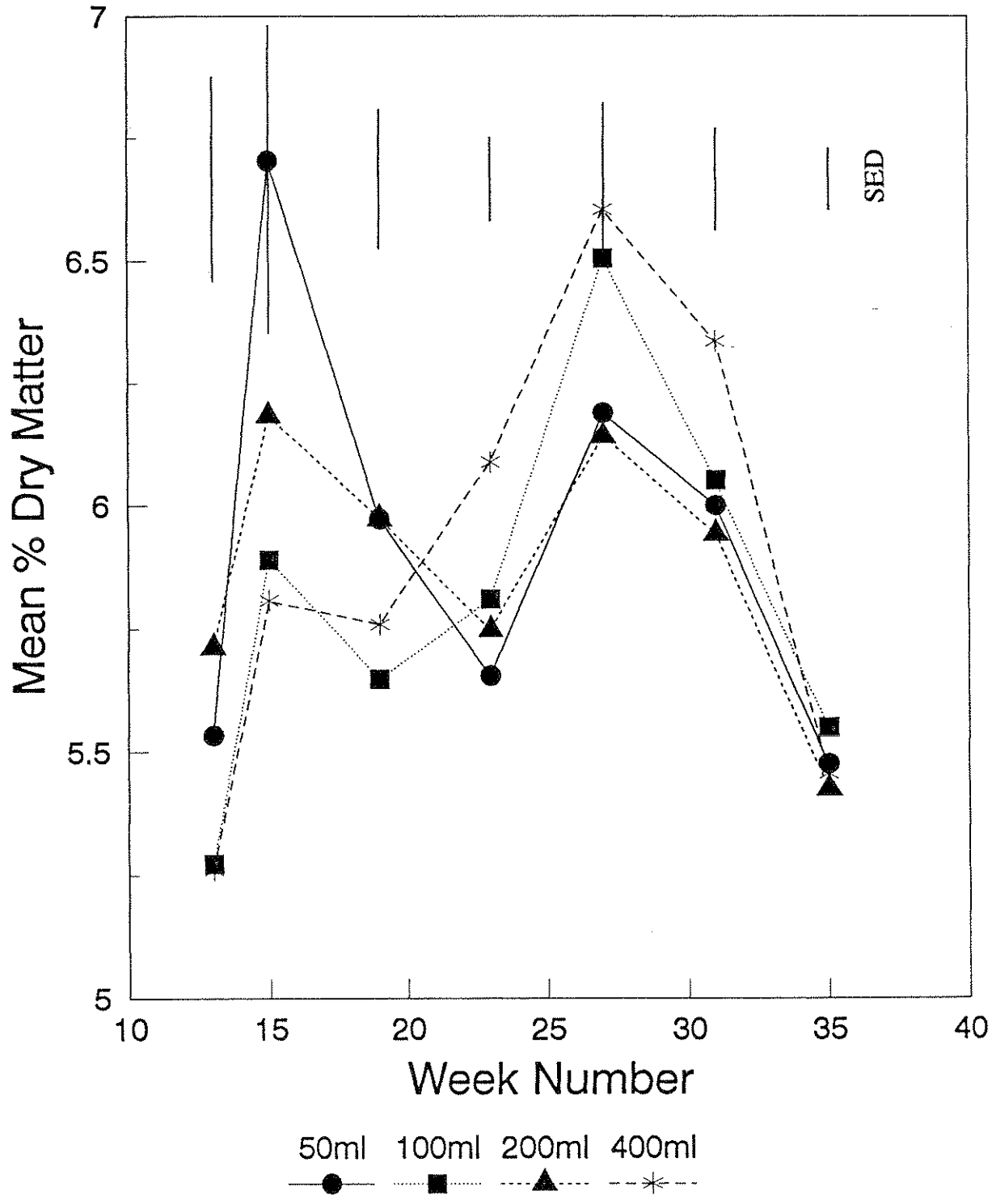
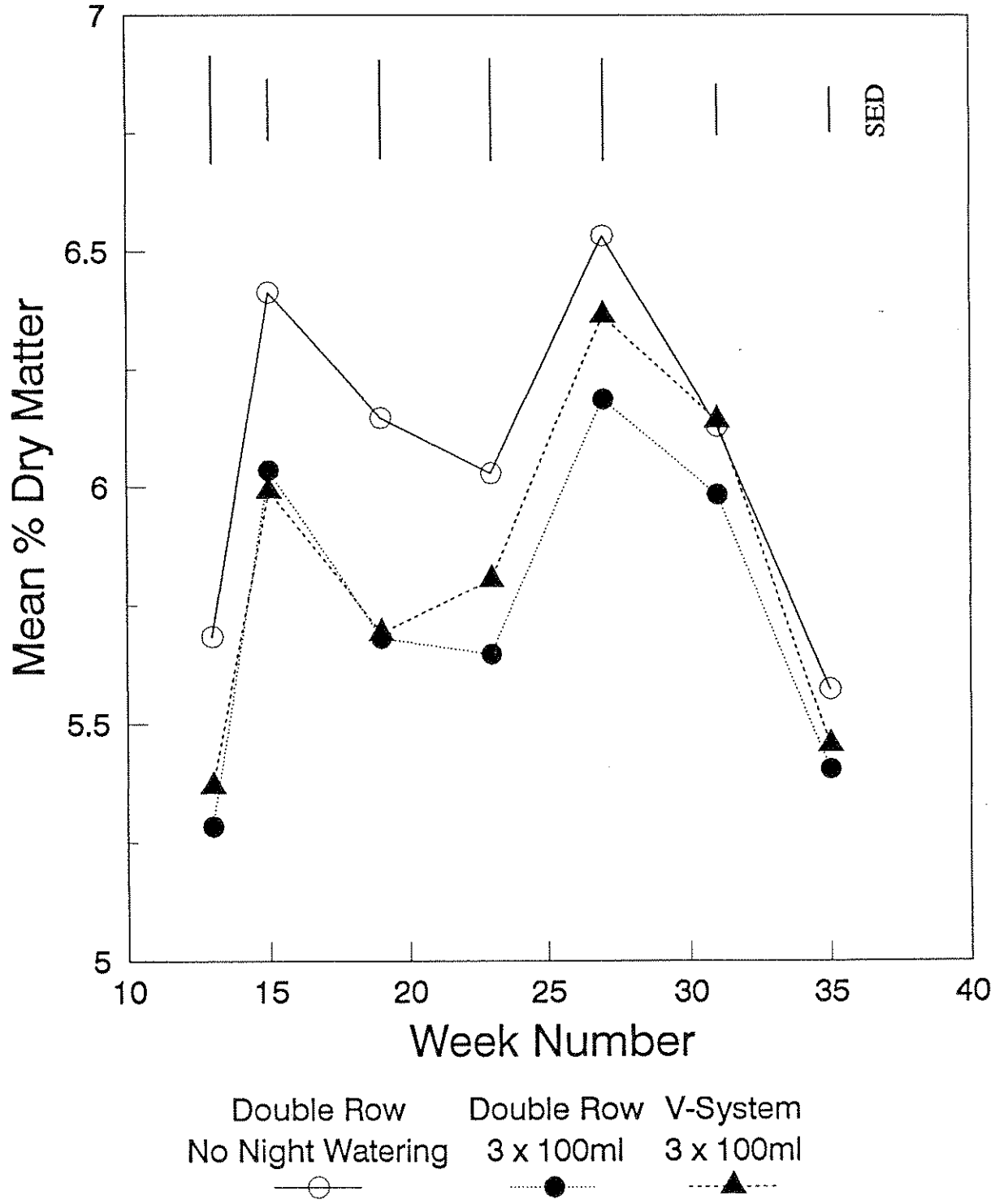


Figure 12. Effect of sub-treatments on Percentage Dry Matter in fruit.



ROOT ENVIRONMENT

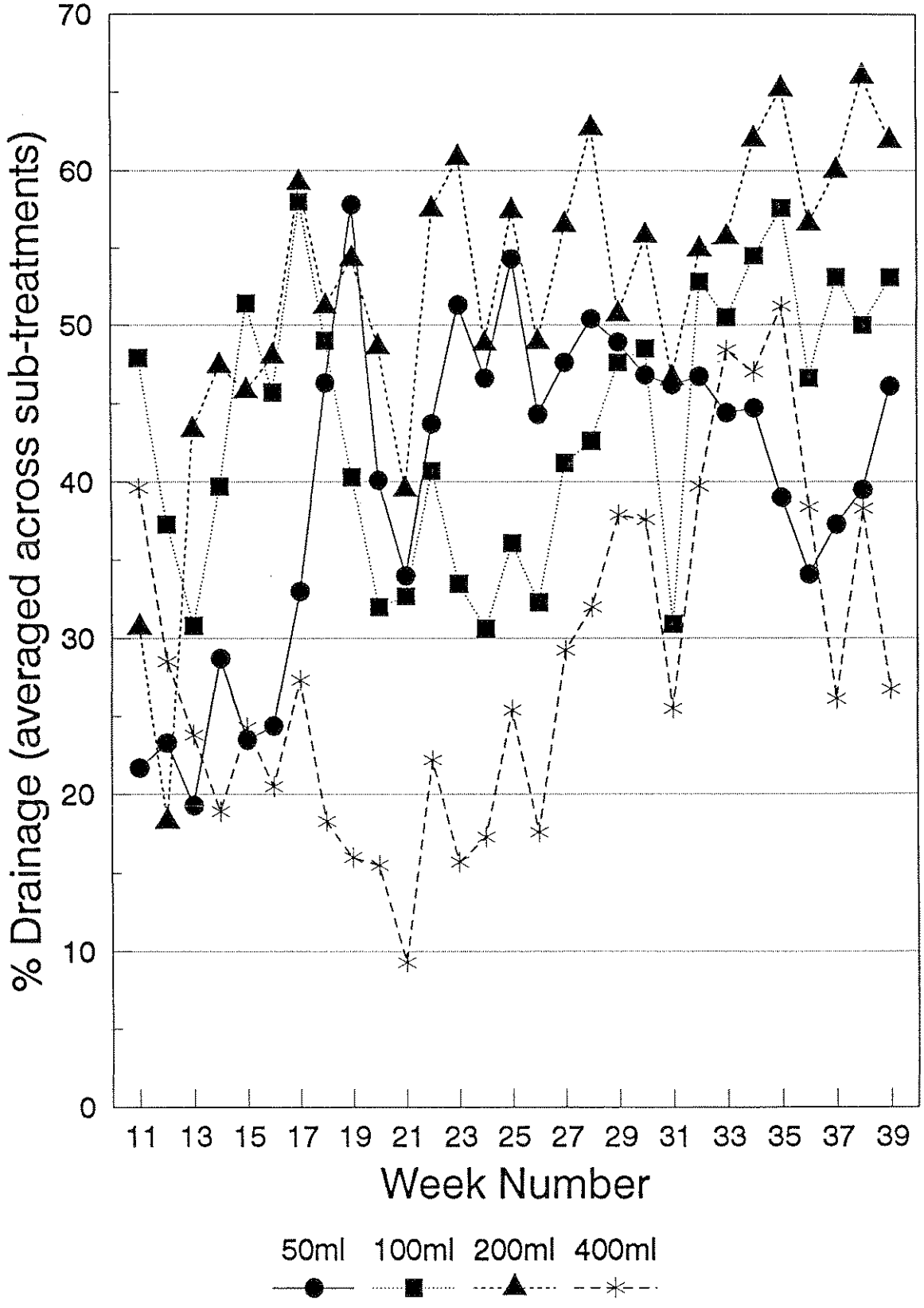
At certain times during the season there were obvious differences in both the percentage drainage and the conductivity of the root zone as influenced by the 'day' regimes and their sub-treatments.

Accurate data on the % drainage was collected daily from week 11 to week 39. Figure 13 (page 32) illustrates these data for the 'day' regimes. During week 11 the average % drainage from the 50 ml regime was c. 21% and during this week slab conductivities rose as high as 10,000 µS. Indeed the relatively low volume of drainage generated by this regime over weeks 11-17 resulted in average slab cf's of 9,000 µS, with a peak of 14,000 µS in week 15. In contrast, applied volumes of 400 mls during this early part of the season, whilst producing similar % drainage figures (with the exception of week 11 when 40% drainage was recorded) seldom resulted in slab cf's exceeding 7,000 µS.

From Figure 13 there is clearly considerable scatter in these data. However, it is evident that from week 17 to 29 the 400 ml regime generated less drainage. Over this period and more specifically week 21-26, when % drainage was at its lowest, slab cf's rose to 8,000 µS on individual days.

Comparison of the double row treatments, both with and without night waterings and the V-system show surprisingly unexpected reductions in the % drainage resulting from the latter of up to 40%. However, at no point were slab cf's observed to be higher in the V-system. These data were not consistent over the season and are therefore not presented here.

Figure 13. Effect of irrigation regimes on the Percentage Drainage.



DISCUSSION

The primary objective of this study was to attempt to optimize the irrigation of a rockwool tomato crop by manipulation of both the irrigation frequency and the volume applied per single application. The effects of these regimes on yield, fruit quality, shelf-life and the root zone environment were assessed.

Manipulation of irrigation regimes as described here had no effect on the time of anthesis, number of fruit set, the date of first fruit pick nor the number of marketable fruit on the first seven trusses. However, there was clear evidence that fruit set on the first truss was reduced for the V-system compared to the conventional double rows.

Irrigation frequency by day had no significant effect on total yield within the context of this study. However, there was a trend evident suggesting that to the end of May the low frequency high volume applications of 400 mls/round produced the highest yields (15.23 kgm^{-2}) in contrast to the 50 ml regime which produced the lowest (13.73 kgm^{-2}). This may reflect the lower slab cf's recorded during the early season in the former regime, and is similar to recent Dutch results reported by Van Gurp and de Bruign (1990).

In contrast, the effect of the sub-treatments on yield was shown to be highly significant, both to the end of May and September.

The absence of night watering throughout the season was clearly detrimental to yield. Comparison of the double rows with and without night watering shows a reduction of 1.59 and 3.47 kgm^{-2} to the end of May and September respectively. These observations may however, simply be attributed to the additional volume applied over 24 h rather than reflecting the benefits of night watering *per se*. Clearly, in the early portion of the season an additional 300 mls applied as three rounds of 100 mls at night may double the total volume over 24 h and even under peak watering conditions may approach an additional 8% relative to the no night watering regime. This is borne out by examination of the gradeout figures (Tables 1 and 2, pages 13 and 14; and Appendix IV, pages 47 to 51) which clearly indicate the smaller average fruit size resulting from the no night watering regime. Furthermore, fruit from the no night watering treatment were high in soluble solids and dry matter relative to other treatments. It is therefore difficult to separate the effects of application at night and total volume of water applied. This also serves to illustrate

the difficulty with factorial experiments of this type where space constrains the number and range of treatments that may be included (refer to conclusions and further work, page 37).

The lower yields recorded from the V-system of 14.06 kgm^{-2} and 47.70 kgm^{-2} to the end of May and September respectively may reflect both poorer early set (Appendix III, page 43) and fractionally smaller fruit size early in the season. Both these factors are likely to have resulted from the high initial plant population of 10,600/acre rather than the system *per se*.

The proportion of Class 1 fruit early in the season reduced markedly from an average of 82% to 65% when the 50 ml regime by day was combined with no night waterings. Although not statistically significant within this study which had minimal replication. Such a reduction commercially would clearly be so. The assessment of overall fruit quality reported here is slightly at variance with the more detailed assessments, as there was no evidence that this reduction in fruit quality could be attributed to a single fruit defect.

Differences in fruit size recorded when comparing those treatments receiving night waterings (Double row and V-system) and those not, may again be attributable to the differences in total volume applied rather than night watering *per se*.

Detailed assessments of fruit physical disorders, internal composition and shelf-life characteristics was only done on seven occasions throughout the season and revealed few significant or consistent treatment effects. Indeed, the relative infrequency of measurements may account for the apparent discrepancy between the overall percentage Class 1 figures and those from the detailed assessments as discussed above. However, a number of general comments may be made. Fruit with the highest levels of Radial Cracking and Netting (Fine Nett Cracking) were picked from plots subjected to a regime of 400 mls/round combined with no night watering. It seems likely that these fruit quality characteristics can be attributed to plants undergoing a degree of water stress with its concomitant effects on the evenness of fruit growth. As a consequence, infrequent watering produced fruit with higher levels of soluble solids and dry matter content. However, the increased incidence of cracking and netting as the season progressed resulted in softer fruit with a much reduced shelf-life.

Fruit quality from V-system plots was not significantly different to that from the double rows.

The relatively low percentage drainage figures recorded for the 50 ml regime during weeks 11-17 (21%) and the resultant high slab cf's are to some degree contradictory to the observations that fruit quality declined over this period. Data not presented here show that for weeks 11-17 the percentage drainage from the 50 ml no night watering combination averaged only 8%. The observation that whilst the application of 400 ml rounds produced similar levels of drainage but lower cf's early in the season possibly reflects the greater diluting potential of these larger volumes.

Drainage from the V-system was surprisingly frequently lower than either of the double row treatments from week 15 until week 39. When this occurred, the percentage drainage was typically between 20 and 30% whereas that from the double rows showed a greater amplitude ranging from 40-65%. One implication of this result is the potential for reduction in nutrient loss to the environment.

In this context these findings are highly relevant to those reported for project PC 55, a secondary objective of which was to assess the potential for reducing Nitrate input to the crop and hence loss to the environment. From Table 3 the influence of the drainage percentage on Nitrate loss can be seen expressed as kg/ha N. Reducing the percentage run off from 50 to 30% with a NO_3-N concentration in the drain of 150 mg/litre would reduce the Nitrate-N loss from 1,050 to 450 kg/ha.

Table 3

Nitrate - N loss from rockwool tomatoes (kg/ha N)

Drainage	NO_3-N Conc. in drainage (mg/l)				
(%)	**100**	**150**	**200**	**250**	**300**
10	78	117	156	195	234
20	175	263	350	440	525
30	300	450	600	750	900
40	470	700	940	1170	1400
50	700	1050	1400	1750	2100

Figures based on a crop water **requirement** of 7 million l^{-1}/ha per season. % drainage calculated from the **total** applied ie. an application of 10 million l^{-1}/ha = 30% drainage.

Data courtesy of Dr Mike Marks (ADAS - Wye)

CONCLUSIONS AND FURTHER WORK

- Manipulation of irrigation regimes as carried out in this study had no effect on anthesis, number of fruit set or the number of marketable fruit.

- Irrigation frequency by day alone had no significant effect on yield or the percentage Class 1 fruit.

- The results indicated that where extreme day regimes of 50 mls or 400 mls per application were combined with no night watering fruit quality and shelf-life were generally reduced.

- Percentage drainage from the V-system was reduced by half in comparison to that recorded from the Double Rows.

Further work :

On completion of the study reported here several key questions remain unresolved.

- What is the effect of applying the same total volume over 24 h and therefore being able to differentiate between the effects of volume alone and true night watering *per se*.

- Are the effects observed influenced by substrate types with differing moisture retention characteristics.

- How are these strategies likely to interact with the V-system.

Work currently being undertaken at HRI Efford (Project PC 82) is designed to answer these questions and thus complement study PC 23c. Details are given overleaf.

The main treatments comprise four irrigation regimes.

(i) A 'standard' regime of 150 ml per plant/100 J cm^{-2} incident radiation as measured by an externally mounted Kipp solarimeter.

(ii) As (i) above with three additional waterings of 100 ml/plant at 23.00, 00.00 and 01.00 h.

ii) As (i) above with three additional waterings of 100 ml/plant at 08.00, 09.00 and 10.00 h.

(iv) As (i) above with three additional waterings of 100 ml/plant at 15.00, 16.00 and 17.00 h.

Sub-treatments :
(substrate x 'system')

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

each of the above substrates is being evaluated both as:

(i) Double row
(ii) 'V'-system

REFERENCES

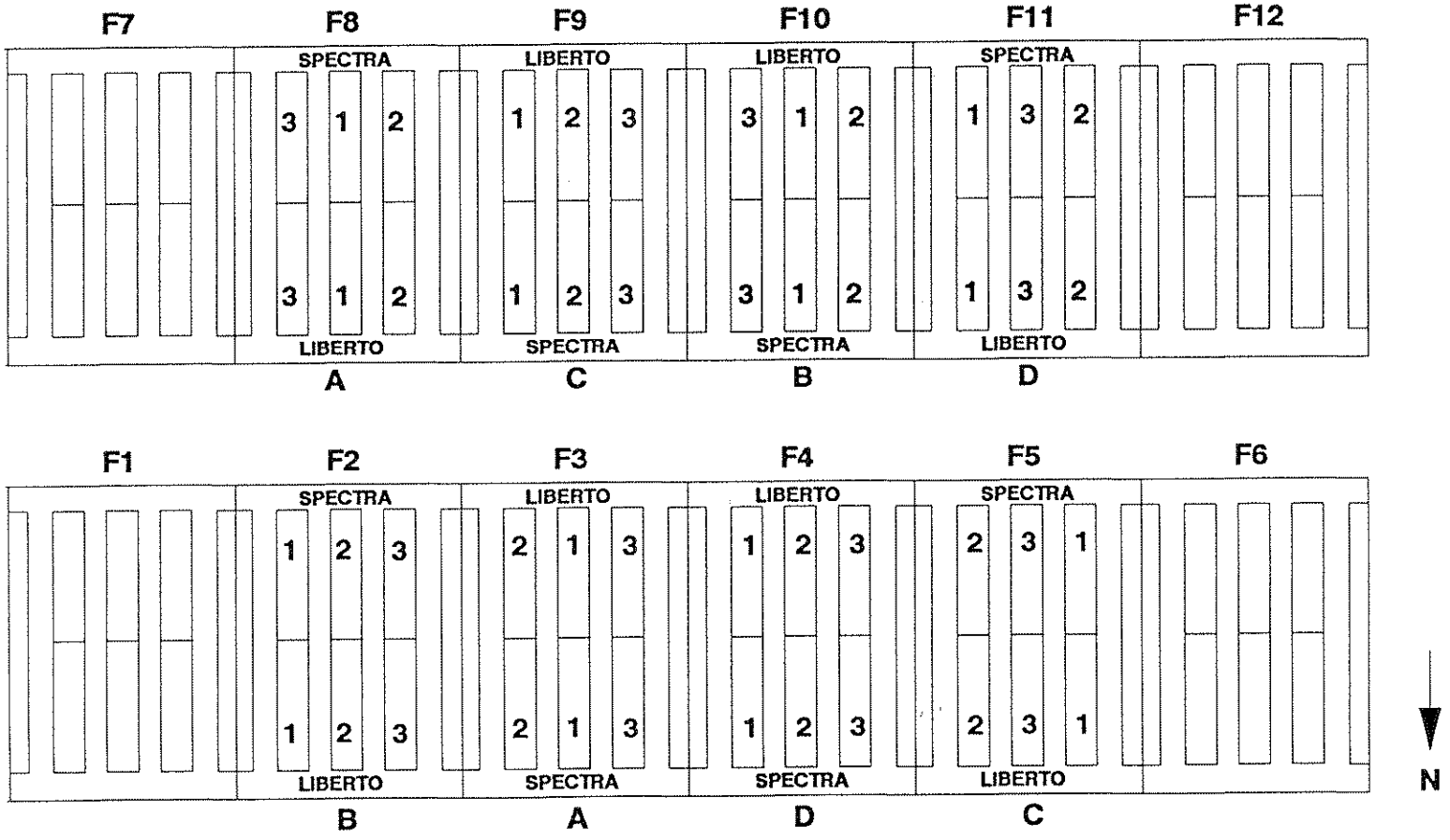
Van Gurp, H and de Bruijn, J. (1990).

Mat volume and frequency of water dose with tomato. *Groenten en Fruit,* September 14.

APPENDICES

HDC IRRIGATION TRIAL 1991/92 PLAN OF TREATMENTS (F-BLOCK)

Appendix I



Main Treatments
A - 50cc per application
B - 100cc per application
C - 200cc per application
D - 400cc per application

Sub Treatments
1 - No night watering
2 - 3 x 100cc at night
3 - 'V' System

Inter Plant Spacing - 476mm
20 plants/m^2 = 2.62 plants/m^2
Plot area = 7.614m^2

Appendix II

Crop Diary

Seed sown	7.11.91
Seedlings blocked on	18.11.91
Plants moved to final growing position and stood on slabs	18.12.91
Slab contact	9.1.92
Treatments commenced	Week 6
First fruit picked	26.2.92
Sideshoots taken on every fourth plant. Population raised from 10,600/acre to 13,250/acre	24.3.92
Final recorded pick and trial terminated	2.10.92

Fungicide Applications

Product	**Date**	**Target**
Rubigan (fenarimol)	10.4.92	Powdery Mildew
Elvaron (dichlofluanid)	17.4.92	*Botrytis*
Brava (chlorothalonil)	9.5.92	*Botrytis*
Rovral (iprodione)	30.5.92	*Botrytis*
Elvaron (dichlofluanid)	27.6.92	*Botrytis*
Elvaron (dichlofluanid)	24.7.92	*Botrytis*

Botrytis stem lesions were painted with Benlate (benomyl) and Actipron paste as observed.

Appendix III

Effect of irrigation regime and variety on the date (day number) of first anthesis of trusses one to seven

Day regime mls/round	Sub-Treatments (Night Watering or V-system)	Variety (Liberto or Spectra)	One	Two	Three	Four	Five	Six	Seven
50	NONE	L	7	19	27	34	40	47	54
		S	9	20	28	35	41	48	56
	3 x 100mls	L	6	19	26	33	40	46	54
		S	8	19	27	35	41	48	56
	V-System	L	7	20	27	34	40	47	55
		S	8	20	28	35	41	48	57
100	NONE	L	6	18	27	33	40	47	55
		S	7	19	28	35	42	49	56
	3 x 100mls	L	7	20	28	35	42	48	56
		S	7	20	28	35	41	48	56
	V-System	L	7	20	27	35	41	48	56
		S	9	21	28	35	42	49	56
200	NONE	L	7	20	28	34	41	47	54
		S	7	21	28	35	41	48	56
	3 x 100mls	L	5	18	26	33	39	46	54
		S	6	20	28	35	41	48	57
	V-System	L	7	19	27	34	41	48	56
		S	8	20	29	35	42	49	56
400	NONE	L	8	20	27	34	40	46	54
		S	7	20	27	34	40	47	55
	3 x 100mls	L	7	19	27	34	40	46	54
		S	7	21	29	35	43	49	57
	V-System	L	6	19	27	33	40	47	54
		S	8	21	28	35	41	48	56
SED (d.f=8)			*1.3*	*1.0*	*0.9*	*0.7*	*0.9*	*1.2*	*1.6*
LSD 5%			*2.9*	*2.3*	*2.1*	*1.6*	*2.1*	*2.7*	*2.6*
Significance			*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*

Appendix III

Effect of irrigation regime and variety on the date (day number) of first fruit pick from trusses one to seven

Day regime mls/round	Sub-Treatments (Night Watering or V-system)	Variety (Liberto or Spectra)	One	Two	Three	Four	Five	Six	Seven
50	NONE	L	63	77	85	93	104	120	120
		S	65	80	86	97	104	122	122
	3 x 100mls	L	63	75	86	94	100	120	120
		S	62	79	92	94	102	120	120
	V-System	L	63	77	89	94	102	120	120
		S	66	82	92	100	107	123	123
100	NONE	L	63	78	86	96	104	122	122
		S	64	78	90	97	111	121	121
	3 x 100mls	L	65	82	91	99	103	120	120
		S	66	81	92	98	104	121	121
	V-System	L	65	79	90	98	104	121	121
		S	66	81	90	95	102	121	121
200	NONE	L	65	79	88	98	104	122	122
		S	64	80	89	99	105	121	121
	3 x 100mls	L	63	78	88	97	101	121	121
		S	63	78	88	99	105	121	121
	V-System	L	66	78	89	98	105	120	120
		S	67	78	91	99	106	122	122
400	NONE	L	66	75	87	96	101	122	122
		S	64	78	89	98	104	123	123
	3 x 100mls	L	63	78	88	95	102	121	121
		S	64	83	91	101	105	123	123
	V-System	L	65	77	88	98	107	120	120
		S	66	82	92	100	106	122	122
SED (d.f=8)			*2.7*	*2.6*	*2.5*	*1.4*	*2.7*	*1.2*	*1.2*
LSD 5%			*6.2*	*6.0*	*3.14*	*8.1*	*6.2*	*2.8*	*2.8*
Significance			*NS*	*NS*	*NS*	*	*NS*	*NS*	*NS*

Appendix III

Effect of irrigation regime and variety on the number of fruit set on trusses one to seven

Day regime mls/round	Sub-Treatments (Night Watering or V-system)	Variety (Liberto or Spectra)	One	Two	Three	Four	Five	Six	Seven
50	NONE	L	6.0	8.6	8.7	9.8	9.4	9.5	9.0
		S	6.0	7.9	8.5	9.0	8.9	8.9	8.5
	3 x 100mls	L	5.4	8.5	8.9	9.9	10.0	10.0	9.6
		S	5.6	8.2	8.7	9.0	8.9	8.9	8.4
	V-System	L	3.5	8.0	9.0	9.2	9.7	9.4	9.2
		S	3.5	7.8	7.8	9.0	8.9	9.0	8.4
100	NONE	L	5.6	8.4	9.1	9.6	9.9	9.9	9.4
		S	6.1	8.8	8.4	9.1	9.1	8.8	8.9
	3 x 100mls	L	6.0	8.6	9.1	9.4	9.7	10.0	9.4
		S	6.2	8.3	8.7	9.5	9.3	9.2	8.6
	V-System	L	5.7	8.4	8.0	9.2	9.4	9.2	9.0
		S	3.3	8.0	8.1	9.0	9.1	9.2	8.9
200	NONE	L	5.5	8.8	8.6	10.0	10.0	10.3	9.7
		S	6.3	8.4	8.3	9.5	9.1	9.1	8.7
	3 x 100mls	L	6.6	8.7	8.2	9.5	10.1	9.8	10.2
		S	6.1	8.5	8.1	8.9	9.1	9.3	8.7
	V-System	L	4.7	9.0	8.4	9.8	10.5	10.0	9.3
		S	4.6	8.1	7.5	8.8	9.3	8.9	8.7
400	NONE	L	5.0	9.0	9.5	10.3	10.6	11.0	9.9
		S	6.0	8.4	8.6	9.2	9.1	9.0	8.5
	3 x 100mls	L	6.4	9.1	8.7	9.9	10.3	10.0	10.0
		S	5.8	8.0	8.7	9.2	9.6	9.2	8.6
	V-System	L	4.7	8.8	8.5	9.7	10.0	9.6	9.9
		S	5.7	8.2	8.3	8.9	9.4	8.9	7.8
SED (d.f=8)			*0.61*	*0.35*	*0.55*	*0.45*	*0.19*	*0.35*	*0.45*
LSD 5%			*1.41*	*0.81*	*1.27*	*1.04*	*0.44*	*0.81*	*1.04*
Significance			*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*

Appendix III

Effect of irrigation regime and variety on the number of marketable fruit on trusses one to seven

Day regime mls/round	Sub-Treatments (Night Watering or V-system)	Variety (Liberto or Spectra)	One	Two	Three	Four	Five	Six	Seven
50	NONE	L	4.0	7.5	8.1	7.8	7.4	7.9	8.2
		S	5.0	7.3	7.9	8.6	7.8	8.2	8.4
	3 x 100mls	L	3.0	7.8	7.5	8.4	8.6	8.2	8.2
		S	4.6	7.5	7.3	7.9	8.4	8.6	8.1
	V-System	L	1.2	6.7	7.0	7.9	8.4	6.5	8.6
		S	2.2	7.0	7.5	7.9	8.5	8.5	8.2
100	NONE	L	4.5	7.5	7.9	8.3	8.9	8.8	8.6
		S	5.8	8.1	8.3	8.3	8.5	8.3	8.4
	3 x 100mls	L	5.4	7.6	8.0	8.2	8.4	7.9	7.7
		S	5.6	7.0	7.9	8.1	8.6	8.1	8.2
	V-System	L	3.6	6.9	8.5	8.0	8.1	7.2	7.0
		S	2.2	7.5	8.3	8.3	8.2	8.3	7.9
200	NONE	L	2.9	7.4	8.2	8.2	8.5	8.1	8.4
		S	5.2	7.4	8.3	8.8	8.5	8.5	8.3
	3 x 100mls	L	6.3	7.7	8.1	8.6	9.2	8.4	8.0
		S	5.6	7.8	8.2	8.2	8.4	8.5	8.3
	V-System	L	1.5	7.3	8.2	7.2	8.0	7.4	7.4
		S	2.0	7.2	7.8	7.5	8.7	8.2	7.8
400	NONE	L	1.8	7.9	8.4	8.0	8.3	8.4	8.7
		S	4.9	7.8	8.0	8.3	8.9	8.8	8.2
	3 x 100mls	L	3.5	7.5	7.5	8.0	8.2	7.4	7.7
		S	4.9	7.0	7.9	8.4	8.5	8.6	7.9
	V-System	L	3.0	7.6	7.0	7.3	8.1	7.6	8.1
		S	4.3	7.4	7.4	8.1	8.3	8.4	7.6
SED (d.f=8)			*1.1*	*0.53*	*0.46*	*0.48*	*0.39*	*0.49*	*0.35*
LSD 5%			*2.53*	*1.22*	*1.06*	*1.10*	*0.90*	*1.13*	*0.81*
Significance			*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*

Appendix IV

Effect of irrigation regime and variety on total yield kgm^{-2}

Day regime mls/round	Mar	Apr	May	Total to May	June	July	Aug	Sept	Total to Sept
50	1.89	4.90	6.93	13.73	8.83	9.18	6.10	10.68	48.52
100	1.89	4.99	7.31	14.20	8.56	8.71	5.79	10.54	47.82
200	2.00	4.92	6.87	13.78	8.77	9.27	6.37	10.68	48.88
400	2.06	5.58	7.59	15.23	8.74	8.44	5.68	10.67	48.76
SED (d.f=3)	*0.176*	*0.600*	*0.748*	*1.217*	*0.474*	*0.143*	*0.405*	*0.282*	*1.058*
LSD 5%	*0.560*	*1.145*	*2.380*	*3.872*	*1.508*	*0.451*	*1.288*	*0.897*	*3.366*
Significance	*NS*	*NS*	*NS*	*NS*	*NS*	*	*NS*	*NS*	*NS*
Night regime or 'V'-system									
None	2.09	4.70	6.73	13.53	8.10	8.79	5.93	10.78	47.16
3 x 100 mls	2.15	5.48	7.49	15.12	9.22	9.24	6.26	10.79	50.63
V-system	1.64	5.11	7.30	14.06	8.85	8.67	5.77	10.36	47.70
SED (d.f=8)	*0.091*	*0.173*	*0.166*	*0.274*	*0.298*	*0.233*	*0.158*	*0.182*	*0.596*
LSD 5%	*0.209*	*0.398*	*0.382*	*0.632*	*0.687*	*0.537*	*0.364*	*0.419*	*1.374*
Significance	**	**	**	***	*	*NS*	*	*NS*	***
Variety									
Liberto	2.05	5.26	7.35	14.66	8.87	9.12	6.31	10.97	49.93
Spectra	1.87	4.93	7.00	13.81	8.58	8.69	5.67	10.31	47.06
SED (d.f=3)	*0.021*	*0.091*	*0.065*	*0.106*	*0.248*	*0.134*	*0.094*	*0.214*	*0.632*
LSD 5%	*0.066*	*0.289*	*0.270*	*0.337*	*0.789*	*0.426*	*0.299*	*0.680*	*2.010*
Significance	**	*	*	**	*NS*	*	**	*NS*	*

Appendix IV

Effect of irrigation regime and variety on percentage Class 1 fruit

Day regime mls/round	Mar	Apr	May	Total to May	June	July	Aug	Sept	Total to Sept
50	83	74	75	76	90	87	88	81	83
100	91	83	84	84	89	82	85	78	84
200	93	80	78	81	88	88	89	77	84
400	93	82	83	84	85	73	81	75	80
SED (d.f=3)	*1.3*	*6.4*	*5.4*	*4.9*	*1.8*	*5.1*	*3.8*	*2.0*	*1.4*
LSD 5%	*4.1*	*20.3*	*17.2*	*15.6*	*5.7*	*16.2*	*12.1*	*6.4*	*4.4*
Significance	*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
Night regime or 'V'-system									
None	87	78	76	78	84	77	83	76	80
3 x 100 mls	92	81	83	83	90	86	87	78	84
V-system	90	80	81	82	89	85	88	79	84
SED (d.f=8)	*0.9*	*2.4*	*3.6*	*2.5*	*1.9*	*4.1*	*1.9*	*0.6*	*1.5*
LSD 5%	*2.1*	*5.5*	*8.3*	*5.7*	*4.4*	*9.4*	*4.4*	*1.4*	*3.4*
Significance	***	*NS*	*NS*	*NS*	*	*NS*	*NS*	*	*
Variety									
Liberto	93	82	78	81	86	79	82	78	81
Spectra	87	77	82	81	89	86	89	77	84
SED (d.f=3)	*2.6*	*1.1*	*0.7*	*0.8*	*1.4*	*1.8*	*2.4*	*1.7*	*1.1*
LSD 5%	*8.3*	*3.5*	*2.2*	*2.5*	*4.4*	*5.7*	*7.6*	*5.4*	*3.5*
Significance	*NS*	*	**	*NS*	*NS*	*	*NS*	*NS*	*NS*

Appendix IV

Effect of irrigation regime and variety on the percentage Class 1 fruit within size grade C (57-64mm diameter)

Day regime mls/round	Mar	Apr	May	Total to May	June	July	Aug	Sept	Total to Sept
50	4	9	16	12	33	39	15	17	23
100	5	10	15	12	21	29	14	12	17
200	4	8	15	11	34	44	19	19	25
400	9	15	18	16	24	27	15	17	20
SED (d.f=3)	*1.7*	*6.2*	*4.7*	*4.9*	*2.4*	*6.5*	*2.2*	*1.2*	*1.1*
LSD 5%	*5.4*	*19.7*	*14.9*	*15.6*	*7.6*	*20.6*	*7.0*	*3.8*	*3.5*
Significance	*NS*	*NS*	*NS*	*NS*	*	*NS*	*NS*	*	*
Night regime or 'V'-system									
None	2	6	10	8	25	32	16	17	19
3 x 100 mls	7	14	19	16	31	39	16	15	23
V-system	7	12	18	15	28	33	15	16	21
SED (d.f=8)	*1.6*	*1.9*	*2.2*	*1.7*	*3.1*	*3.5*	*1.9*	*1.4*	*1.7*
LSD 5%	*3.7*	*4.4*	*5.1*	*3.9*	*7.1*	*8.1*	*4.4*	*3.2*	*3.9*
Significance	*	**	***	**	*NS*	*NS*	*NS*	*NS*	*NS*
Variety									
Liberto	7	12	15	13	25	31	11	11	18
Spectra	4	9	16	12	32	38	20	21	24
SED (d.f=3)	*1.4*	*1.9*	*1.3*	*1.0*	*0.8*	*1.0*	*1.0*	*1.1*	*0.4*
LSD 5%	*4.4*	*6.0*	*4.1*	*3.2*	*2.5*	*3.2*	*3.2*	*3.5*	*1.3*
Significance	*NS*	*NS*	*NS*	*NS*	**	**	**	**	***

Appendix IV

Effect of irrigation regime and variety on the percentage Class 1 fruit within size grade D (47-57mm diameter)

Day regime mls/round	Mar	Apr	May	Total to May	June	July	Aug	Sept	Total to Sept
50	69	70	69	69	59	57	74	73	66
100	75	71	70	71	68	65	74	77	71
200	76	74	73	73	59	52	72	71	66
400	80	73	70	72	66	65	74	74	70
SED (d.f=3)	*6.4*	*3.2*	*1.6*	*2.0*	*1.9*	*5.1*	*2.3*	*1.3*	*1.9*
LSD 5%	*20.4*	*10.2*	*5.1*	*6.4*	*6.0*	*16.2*	*7.3*	*4.1*	*6.0*
Significance	*NS*	*NS*	*NS*	*NS*	*	*NS*	*NS*	*NS*	*NS*
Night regime or 'V'-system									
None	70	70	73	71	65	61	74	73	69
3 x 100 mls	78	73	69	71	61	57	73	74	67
V-system	76	73	70	72	63	61	73	74	69
SED (d.f=8)	*3.5*	*2.3*	*2.1*	*1.7*	*2.5*	*3.0*	*1.3*	*1.5*	*1.4*
LSD 5%	*8.1*	*5.3*	*4.8*	*3.9*	*5.7*	*6.9*	*2.9*	*3.4*	*3.2*
Significance	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
Variety									
Liberto	74	71	72	72	66	63	77	78	71
Spectra	76	72	69	71	60	56	70	69	66
SED (d.f=3)	*1.0*	*2.3*	*0.4*	*1.0*	*0.5*	*0.8*	*0.9*	*1.3*	*0.5*
LSD 5%	*3.2*	*7.3*	*1.3*	*3.2*	*1.6*	*2.5*	*2.8*	*4.1*	*1.6*
Significance	*NS*	*NS*	**	*NS*	***	**	**	**	***

Appendix IV

Effect of irrigation regime and variety on the percentage Class 1 fruit within size grade E (40-47mm diameter)

Day regime mls/round	Mar	Apr	May	Total to May	June	July	Aug	Sept	Total to Sept
50	27	20	15	18	7	4	10	9	10
100	20	18	14	16	10	6	11	10	11
200	20	18	12	15	6	3	8	9	9
400	11	11	11	11	10	7	11	8	9
SED (d.f=3)	*7.8*	*9.2*	*4.7*	*6.8*	*1.3*	*1.5*	*1.2*	*0.5*	*1.2*
LSD 5%	*24.8*	*29.3*	*14.9*	*21.6*	*4.1*	*4.7*	*3.8*	*1.6*	*3.8*
Significance	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
Night regime or 'V'-system									
None	27	24	16	20	9	6	10	9	11
3 x 100 mls	15	13	12	12	7	4	10	9	9
V-system	16	14	11	13	8	5	10	9	9
SED (d.f=8)	*3.9*	*2.5*	*1.7*	*1.9*	*0.8*	*0.8*	*0.8*	*1.1*	*0.5*
LSD 5%	*8.1*	*5.3*	*4.8*	*3.9*	*5.7*	*6.9*	*2.9*	*3.4*	*3.2*
Significance	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
Variety									
Liberto	74	71	72	72	66	63	77	78	71
Spectra	76	72	69	71	60	56	70	69	66
SED (d.f=3)	*1.0*	*2.3*	*0.4*	*1.0*	*0.5*	*0.8*	*0.9*	*1.3*	*0.5*
LSD 5%	*3.2*	*7.3*	*1.3*	*3.2*	*1.6*	*2.5*	*2.8*	*4.1*	*1.6*
Significance	*NS*	*NS*	**	*NS*	***	**	**	**	***

Appendix V

Effect of irrigation regime and variety on the level of fruit disorders (Figures are a mean of 10 fruit from each of two replicates)

Week Number 13

Day regime mls/round	Sub Treatments (Night watering or V-System)	Variety (Liberto or Spectra)	Boxiness	Nippling	Ribbing	Slab Sided	Radial Cracking	Netting	Gold Spot	Gold Marbling	Red Noses	Blotchy Ripening
50	NONE	L	0.00	0.00	0.25	0.35	0.00	0.00	0.00	1.30	0.00	0.00
		S	0.00	0.10	0.25	0.40	0.00	0.00	0.00	1.15	0.00	0.00
	3 x 100mls	L	0.00	0.10	0.15	0.50	0.00	0.00	0.00	1.25	0.00	0.00
		S	0.00	0.25	0.20	0.50	0.00	0.00	0.00	1.50	0.00	0.00
	V-System	L	0.00	0.15	0.30	0.55	0.00	0.10	0.00	1.15	0.00	0.00
		S	0.00	0.10	0.50	0.40	0.00	0.00	0.00	1.40	0.00	0.00
100	NONE	L	0.00	0.05	0.00	0.45	0.15	0.25	0.00	1.25	0.00	0.00
		S	0.00	0.10	0.15	0.50	0.00	0.10	0.00	1.30	0.00	0.00
	3 x 100mls	L	0.00	0.10	0.05	0.45	0.00	0.30	0.00	0.65	0.00	0.00
		S	0.00	0.05	0.20	0.40	0.00	0.05	0.00	1.05	0.00	0.00
	V-System	L	0.00	0.00	0.20	0.40	0.00	0.10	0.05	0.75	0.00	0.00
		S	0.10	0.30	0.15	0.55	0.00	0.00	0.00	1.50	0.00	0.00
200	NONE	L	0.00	0.05	0.05	0.55	0.00	0.00	0.00	1.10	0.00	0.00
		S	0.00	0.30	0.40	0.50	0.00	0.00	0.00	1.35	0.00	0.00
	3 x 100mls	L	0.00	0.10	0.10	0.55	0.00	0.00	0.00	1.15	0.00	0.00
		S	0.00	0.30	0.20	0.60	0.00	0.00	0.00	1.10	0.00	0.00
	V-System	L	0.00	0.00	0.00	0.15	0.10	0.15	0.00	0.50	0.00	0.00
		S	0.00	0.15	0.15	0.50	0.00	0.05	0.00	0.45	0.00	0.00
400	NONE	L	0.00	0.00	0.20	0.30	0.00	0.05	0.05	1.70	0.00	0.00
		S	0.05	0.15	0.15	0.35	0.00	0.00	0.00	1.20	0.00	0.00
	3 x 100mls	L	0.00	0.00	0.05	0.35	0.00	0.05	0.00	0.70	0.00	0.00
		S	0.00	0.20	0.25	0.35	0.00	0.00	0.00	0.90	0.00	0.00
	V-System	L	0.05	0.05	0.10	0.50	0.00	0.00	0.00	0.90	0.00	0.00
		S	0.00	0.05	0.10	0.40	0.00	0.00	0.05	0.85	0.00	0.00

Appendix V

Effect of irrigation regime and variety on the level of fruit disorders (Figures are a mean of 10 fruit from each of two replicates)

Week Number 15

Day regime mls/round	Sub Treatments (Night watering or V-System)	Variety (Liberto or Spectra)	Boxiness	Nippling	Ribbing	Slab Sided	Radial Cracking	Netting	Gold Spot	Gold Marbling	Red Noses	Blotchy Ripening
50	NONE	L	0.05	0.05	0.10	0.15	0.00	0.20	0.00	1.05	0.00	0.00
		S	0.00	0.10	0.05	0.20	0.10	0.10	0.00	0.95	0.00	0.00
	3 x 100mls	L	0.00	0.00	0.00	0.25	0.35	0.20	0.00	1.10	0.00	0.00
		S	0.00	0.10	0.25	0.60	0.00	0.05	0.00	0.80	0.00	0.00
	V-System	L	0.05	0.00	0.10	0.30	0.10	0.05	0.05	0.50	0.00	0.00
		S	0.00	0.15	0.15	0.10	0.00	0.15	0.05	1.30	0.00	0.00
100	NONE	L	0.05	0.00	0.25	0.20	0.00	0.00	0.10	0.40	0.00	0.00
		S	0.05	0.05	0.20	0.30	0.00	0.00	0.00	0.95	0.00	0.00
	3 x 100mls	L	0.15	0.00	0.25	0.45	0.00	0.05	0.00	0.25	0.00	0.00
		S	0.00	0.15	0.20	0.20	0.00	0.05	0.00	0.75	0.00	0.05
	V-System	L	0.25	0.10	0.00	0.45	0.05	0.05	0.00	0.50	0.00	0.00
		S	0.05	0.10	0.40	0.35	0.00	0.05	0.00	0.55	0.00	0.00
200	NONE	L	0.05	0.00	0.55	0.25	0.00	0.00	0.00	0.65	0.00	0.00
		S	0.00	0.15	0.15	0.30	0.00	0.00	0.00	0.80	0.00	0.00
	3 x 100mls	L	0.15	0.00	0.10	0.05	0.00	0.00	0.20	1.05	0.00	0.00
		S	0.05	0.00	0.00	0.30	0.00	0.00	0.05	1.45	0.00	0.00
	V-System	L	0.35	0.05	0.05	0.40	0.00	0.00	0.00	0.40	0.00	0.00
		S	0.25	0.15	0.20	0.35	0.00	0.00	0.00	1.15	0.00	0.00
400	NONE	L	0.10	0.00	0.10	0.35	0.00	0.00	0.30	0.75	0.00	0.00
		S	0.00	0.10	0.30	0.30	0.00	0.00	0.00	1.35	0.00	0.00
	3 x 100mls	L	0.15	0.00	0.40	0.25	0.00	0.00	0.00	0.60	0.00	0.00
		S	0.00	0.20	0.20	0.30	0.05	0.10	0.00	1.65	0.00	0.00
	V-System	L	0.20	0.05	0.30	0.40	0.00	0.05	0.00	0.50	0.00	0.00
		S	0.00	0.05	0.50	0.55	0.00	0.00	0.00	0.55	0.00	0.00

Appendix V

Effect of irrigation regime and variety on the level of fruit disorders (Figures are a mean of 10 fruit from each of two replicates)

Week Number 19

Day regime mls/round	Sub Treatments (Night watering or V-System)	Variety (Liberto or Spectra)	Boxiness	Nippling	Ribbing	Slab Sided	Radial Cracking	Netting	Gold Spot	Gold Marbling	Red Noses	Blotchy Ripening
50	NONE	L	0.15	0.00	0.25	0.15	0.15	0.30	0.15	0.55	0.00	0.05
		S	0.00	0.00	0.00	0.15	0.00	0.20	0.00	0.50	0.00	0.05
	3 x 100mls	L	0.05	0.00	0.10	0.10	0.20	0.35	0.25	0.45	0.00	0.10
		S	0.00	0.00	0.15	0.00	0.00	0.15	0.05	1.10	0.00	0.05
	V-System	L	0.10	0.00	0.15	0.10	0.00	0.20	0.10	0.40	0.00	0.00
		S	0.00	0.00	0.15	0.05	0.30	0.40	0.00	0.35	0.00	0.00
100	NONE	L	0.10	0.00	0.05	0.20	0.00	0.00	0.10	0.55	0.00	0.00
		S	0.00	0.00	0.10	0.20	0.45	0.00	0.05	0.55	0.00	0.00
	3 x 100mls	L	0.10	0.00	0.25	0.15	0.00	0.05	0.00	0.60	0.00	0.00
		S	0.00	0.00	0.00	0.05	0.05	0.00	0.10	0.45	0.00	0.00
	V-System	L	0.25	0.00	0.05	0.35	0.05	0.25	0.00	0.80	0.00	0.10
		S	0.00	0.00	0.20	0.15	0.00	0.00	0.00	0.70	0.00	0.00
200	NONE	L	0.10	0.00	0.10	0.10	0.00	0.10	0.15	0.40	0.00	0.00
		S	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.65	0.00	0.00
	3 x 100mls	L	0.15	0.00	0.20	0.20	0.10	0.05	0.05	0.20	0.00	0.00
		S	0.05	0.00	0.35	0.25	0.00	0.00	0.00	0.55	0.00	0.00
	V-System	L	0.25	0.00	0.30	0.15	0.20	0.60	0.00	0.55	0.00	0.00
		S	0.05	0.00	0.05	0.25	0.15	0.70	0.05	0.50	0.00	0.00
400	NONE	L	0.15	0.00	0.25	0.20	0.00	0.00	0.25	0.60	0.00	0.00
		S	0.00	0.00	0.00	0.05	0.00	0.00	0.10	0.55	0.00	0.05
	3 x 100mls	L	0.10	0.00	0.05	0.30	0.00	0.00	0.15	0.25	0.00	0.00
		S	0.15	0.00	0.10	0.05	0.15	0.25	0.00	1.15	0.00	0.05
	V-System	L	0.35	0.00	0.20	0.30	0.10	0.35	0.00	0.35	0.00	0.00
		S	0.10	0.00	0.25	0.35	0.05	0.00	0.00	0.95	0.00	0.05

Appendix V

Effect of irrigation regime and variety on the level of fruit disorders (Figures are a mean of 10 fruit from each of two replicates)

Week Number 23

Day regime mls/round	Sub Treatments (Night watering or V-System)	Variety (Liberto or Spectra)	Boxiness	Nippling	Ribbing	Slab Sided	Radial Cracking	Netting	Gold Spot	Gold Marbling	Red Noses	Blotchy Ripening
50	NONE	L	0.30	0.25	0.10	0.05	0.00	0.20	0.55	0.45	0.00	0.10
		S	0.00	0.00	0.05	0.00	0.00	0.15	0.80	0.15	0.00	0.35
	3 x 100mls	L	0.05	0.45	0.00	0.05	0.00	0.05	1.00	0.15	0.00	0.05
		S	0.00	0.10	0.05	0.05	0.00	0.15	0.45	0.15	0.00	0.25
	V-System	L	0.10	0.05	0.00	0.00	0.00	0.00	0.70	0.20	0.00	0.10
		S	0.00	0.15	0.10	0.05	0.00	0.15	0.80	0.35	0.00	0.15
100	NONE	L	0.05	0.15	0.35	0.05	0.00	0.00	1.20	0.25	0.00	0.20
		S	0.00	0.20	0.05	0.00	0.00	0.65	0.60	0.30	0.00	0.40
	3 x 100mls	L	0.00	0.35	0.15	0.00	0.00	0.00	1.25	0.15	0.00	0.10
		S	0.00	0.15	0.15	0.05	0.05	0.10	1.10	0.15	0.00	0.10
	V-System	L	0.15	0.00	0.20	0.25	0.00	0.00	0.80	0.05	0.00	0.15
		S	0.05	0.00	0.10	0.10	0.00	0.00	0.85	0.30	0.00	0.10
200	NONE	L	0.05	0.00	0.15	0.05	0.00	0.05	0.85	0.50	0.00	0.05
		S	0.00	0.30	0.00	0.00	0.00	0.00	1.25	0.10	0.00	0.10
	3 x 100mls	L	0.30	0.10	0.65	0.40	0.00	0.00	1.00	0.20	0.00	0.30
		S	0.00	0.15	0.10	0.00	0.00	0.00	0.95	0.15	0.00	0.10
	V-System	L	0.25	0.05	0.20	0.45	0.00	0.15	0.75	0.25	0.00	0.20
		S	0.00	0.20	0.05	0.05	0.00	0.05	0.90	0.15	0.00	0.35
400	NONE	L	0.05	0.20	0.15	0.15	0.00	0.00	1.20	0.10	0.00	0.05
		S	0.00	0.10	0.05	0.05	0.00	0.10	0.45	0.20	0.00	0.25
	3 x 100mls	L	0.30	0.00	0.05	0.05	0.00	0.00	1.05	0.25	0.00	0.25
		S	0.00	0.20	0.10	0.10	0.00	0.00	0.35	0.05	0.05	0.10
	V-System	L	0.30	0.20	0.15	0.15	0.00	0.00	1.00	0.20	0.00	0.00
		S	0.05	0.10	0.15	0.00	0.00	0.05	0.80	0.00	0.00	0.05

Appendix V

Effect of irrigation regime and variety on the level of fruit disorders (Figures are a mean of 10 fruit from each of two replicates)

Week Number 27

Day regime mls/round	Sub Treatments (Night watering or V-System)	Variety (Liberto or Spectra)	Boxiness	Nippling	Ribbing	Slab Sided	Radial Cracking	Netting	Gold Spot	Gold Marbling	Red Noses	Blotchy Ripening
50	NONE	L	0.00	0.05	0.00	0.00	0.00	0.05	0.85	1.25	0.00	0.10
		S	0.00	0.15	0.00	0.00	0.00	0.05	0.70	0.40	0.00	0.40
	3 x 100mls	L	0.00	0.00	0.10	0.10	0.00	0.00	0.75	1.00	0.00	0.35
		S	0.00	0.05	0.00	0.00	0.00	0.20	0.25	0.10	0.00	0.25
	V-System	L	0.00	0.05	0.00	0.00	0.00	0.20	0.50	1.00	0.00	0.50
		S	0.00	0.10	0.00	0.00	0.00	0.00	0.25	0.50	0.00	0.40
100	NONE	L	0.20	0.00	0.00	0.00	0.00	0.05	0.65	0.70	0.00	0.05
		S	0.00	0.10	0.15	0.00	0.00	0.05	0.80	0.55	0.00	0.35
	3 x 100mls	L	0.00	0.10	0.00	0.00	0.00	0.00	0.60	0.45	0.00	0.15
		S	0.00	0.05	0.10	0.00	0.05	0.15	0.30	0.50	0.00	0.20
	V-System	L	0.00	0.00	0.00	0.05	0.45	0.25	0.30	1.30	0.00	0.20
		S	0.00	0.05	0.05	0.05	0.00	0.00	0.40	0.40	0.00	0.10
200	NONE	L	0.00	0.15	0.00	0.00	0.00	0.00	0.80	0.40	0.00	0.05
		S	0.00	0.05	0.05	0.05	0.00	0.25	0.35	0.50	0.00	0.20
	3 x 100mls	L	0.00	0.10	0.00	0.10	0.00	0.00	1.25	0.90	0.00	0.25
		S	0.00	0.00	0.05	0.05	0.20	0.75	0.25	1.15	0.00	0.35
	V-System	L	0.00	0.05	0.15	0.00	0.00	0.10	0.50	0.65	0.00	0.30
		S	0.00	0.05	0.15	0.00	0.00	0.00	0.50	0.35	0.00	0.25
400	NONE	L	0.00	0.20	0.05	0.10	0.20	0.00	0.70	1.60	0.00	0.10
		S	0.00	0.05	0.00	0.00	0.15	0.15	0.15	0.30	0.00	0.00
	3 x 100mls	L	0.00	0.05	0.00	0.00	0.00	0.05	0.45	1.15	0.00	0.15
		S	0.00	0.05	0.10	0.00	0.05	0.10	0.35	0.40	0.00	0.35
	V-System	L	0.00	0.05	0.00	0.05	0.00	0.00	0.65	0.40	0.00	0.20
		S	0.00	0.05	0.00	0.05	0.00	0.05	0.15	0.15	0.00	0.15

Appendix V

Effect of irrigation regime and variety on the level of fruit disorders (Figures are a mean of 10 fruit from each of two replicates)

Week Number 31

Day regime mls/round	Sub Treatments (Night watering or V-System)	Variety (Liberto or Spectra)	Boxiness	Nippling	Ribbing	Slab Sided	Radial Cracking	Netting	Gold Spot	Gold Marbling	Red Noses	Blotchy Ripening
50	NONE	L	0.25	0.15	0.05	0.30	0.10	0.50	1.25	1.10	0.00	0.05
		S	0.10	0.00	0.00	0.05	0.45	0.85	0.40	0.80	0.15	0.05
	3 x 100mls	L	0.15	0.05	0.05	0.40	0.00	0.00	1.35	0.40	0.00	0.25
		S	0.00	0.00	0.00	0.05	0.05	0.40	0.95	0.35	0.00	0.30
	V-System	L	0.25	0.00	0.00	0.30	0.00	0.15	1.00	0.50	0.05	0.10
		S	0.00	0.00	0.10	0.05	0.35	0.05	0.45	0.40	0.00	0.10
100	NONE	L	0.05	0.00	0.20	0.20	0.40	0.05	1.05	1.25	0.00	0.05
		S	0.00	0.10	0.10	0.15	0.45	0.45	1.00	0.20	0.00	0.15
	3 x 100mls	L	0.00	0.00	0.00	0.30	0.20	0.35	0.70	1.10	0.00	0.10
		S	0.00	0.00	0.00	0.05	0.30	0.70	0.90	0.25	0.00	0.05
	V-System	L	0.05	0.00	0.00	0.10	0.10	0.35	0.90	1.05	0.00	0.10
		S	0.00	0.00	0.00	0.05	0.25	0.75	0.80	0.20	0.00	0.00
200	NONE	L	0.05	0.10	0.05	0.20	0.00	0.25	1.35	0.30	0.00	0.20
		S	0.00	0.00	0.05	0.05	0.05	0.35	1.10	0.10	0.00	0.60
	3 x 100mls	L	0.05	0.05	0.10	0.25	0.05	0.35	1.30	0.90	0.00	0.05
		S	0.00	0.00	0.05	0.05	0.10	0.30	1.05	0.40	0.00	0.40
	V-System	L	0.20	0.00	0.25	0.55	0.05	0.35	1.15	0.55	0.00	0.00
		S	0.00	0.00	0.00	0.10	0.15	0.60	1.05	0.30	0.00	0.20
400	NONE	L	0.05	0.10	0.00	0.05	0.70	0.75	0.20	1.25	0.15	0.05
		S	0.00	0.05	0.00	0.00	0.15	1.05	0.15	0.45	0.00	0.15
	3 x 100mls	L	0.05	0.00	0.10	0.10	0.15	0.35	1.10	0.55	0.00	0.15
		S	0.10	0.00	0.10	0.10	0.40	0.80	0.25	0.40	0.00	0.10
	V-System	L	0.15	0.00	0.10	0.25	0.00	0.35	1.00	0.55	0.00	0.20
		S	0.00	0.00	0.05	0.00	0.05	0.15	0.40	0.35	0.00	0.15

Appendix V

Effect of irrigation regime and variety on the level of fruit disorders (Figures are a mean of 10 fruit from each of two replicates)

Week Number 35

Day regime mls/round	Sub Treatments (Night watering or V-System)	Variety (Liberto or Spectra)	Boxiness	Nippling	Ribbing	Slab Sided	Radial Cracking	Netting	Gold Spot	Gold Marbling	Red Noses	Blotchy Ripening
50	NONE	L	0.00	0.00	0.00	0.45	0.00	0.60	0.95	0.10	0.15	0.20
		S	0.00	0.00	0.05	0.15	0.25	0.85	1.05	0.40	0.10	0.25
	3 x 100mls	L	0.15	0.05	0.00	0.20	0.00	0.15	0.55	0.10	0.00	0.05
		S	0.05	0.00	0.00	0.20	0.10	0.40	0.70	0.05	0.00	0.15
	V-System	L	0.10	0.00	0.05	0.25	0.00	0.35	0.90	0.00	0.15	0.15
		S	0.00	0.05	0.05	0.30	0.10	0.90	0.90	0.00	0.10	0.20
100	NONE	L	0.10	0.00	0.00	0.40	0.05	0.15	0.95	0.05	0.10	0.00
		S	0.00	0.00	0.10	0.25	0.00	0.55	1.00	0.35	0.00	0.20
	3 x 100mls	L	0.10	0.10	0.00	0.60	0.05	0.25	0.75	0.00	0.15	0.10
		S	0.05	0.10	0.05	0.05	0.00	0.55	0.90	0.00	0.00	0.00
	V-System	L	0.00	0.15	0.05	0.75	0.00	0.75	0.95	0.05	0.10	0.00
		S	0.00	0.00	0.05	0.10	0.20	0.95	1.10	0.05	0.10	0.20
200	NONE	L	0.05	0.00	0.00	0.50	0.00	0.45	0.85	0.10	0.10	0.35
		S	0.00	0.10	0.00	0.25	0.00	0.80	1.20	0.00	0.10	0.00
	3 x 100mls	L	0.00	0.00	0.00	0.35	0.00	0.40	0.45	0.10	0.00	0.15
		S	0.05	0.00	0.10	0.30	0.05	0.55	1.20	0.10	0.15	0.05
	V-System	L	0.00	0.00	0.05	0.40	0.00	0.15	0.90	0.00	0.30	0.20
		S	0.00	0.05	0.00	0.20	0.00	0.80	1.20	0.10	0.00	0.10
400	NONE	L	0.05	0.05	0.00	0.15	0.50	0.90	0.10	0.40	0.05	0.15
		S	0.00	0.00	0.00	0.20	0.35	1.05	0.35	0.00	0.10	0.10
	3 x 100mls	L	0.00	0.10	0.00	0.15	0.00	0.50	0.65	0.05	0.05	0.15
		S	0.00	0.05	0.05	0.25	0.00	0.30	0.50	0.30	0.10	0.35
	V-System	L	0.00	0.00	0.00	0.25	0.00	0.70	1.45	0.05	0.05	0.00
		S	0.00	0.05	0.05	0.30	0.00	0.80	1.05	0.15	0.05	0.25

Appendix VI

Effect of irrigation regime and variety on shelf-life and fruit internal composition (Figures are a mean of 10 fruit from each of two replicates)

Week Number 13

Day regime mls/round	Sub Treatments (Night watering or V-System)	Variety (Liberto or Spectra)	Compression (mm)	Endpoint pH	% Soluble Solids	% Weight Loss (6 days)	% Dry Matter
50	NONE	L	2.63	6.94	5.20	2.38	6.01
		S	2.54	7.42	4.85	2.59	5.93
	3 x 100mls	L	2.74	7.28	4.65	2.90	4.96
		S	2.89	7.17	4.85	2.96	5.39
	V-System	L	2.63	7.48	4.40	2.69	5.48
		S	2.71	6.94	4.75	3.14	5.45
100	NONE	L	2.79	7.71	4.30	2.61	5.31
		S	2.99	7.65	4.45	1.87	5.75
	3 x 100mls	L	3.07	7.42	4.25	3.17	5.01
		S	3.00	7.23	4.50	3.43	5.38
	V-System	L	3.09	7.95	4.25	4.43	4.87
		S	3.09	7.53	4.70	4.34	5.32
200	NONE	L	2.83	7.02	4.55	2.81	5.40
		S	2.92	7.26	4.95	2.95	6.31
	3 x 100mls	L	2.68	7.35	4.60	4.41	5.86
		S	2.97	7.34	4.60	3.94	5.36
	V-System	L	2.69	7.22	4.75	2.72	5.66
		S	2.71	7.16	4.95	3.11	5.71
400	NONE	L	2.72	7.12	4.65	2.49	5.24
		S	2.87	7.23	4.45	3.07	5.54
	3 x 100mls	L	2.59	7.55	4.35	3.18	5.09
		S	2.92	7.30	4.50	3.35	5.24
	V-System	L	2.80	7.32	4.40	3.00	5.21
		S	3.02	7.07	4.70	3.37	5.25

Appendix VI

Effect of irrigation regime and variety on shelf-life and fruit internal composition (Figures are a mean of 10 fruit from each of two replicates)

Week Number 15

Day regime mls/round	Sub Treatments (Night watering or V-System)	Variety (Liberto or Spectra)	Compression (mm)	Endpoint pH	% Soluble Solids	% Weight Loss (6 days)	% Dry Matter
50	NONE	L	2.70	7.15	5.65	2.38	6.01
		S	2.49	7.33	5.35	2.59	5.93
	3 x 100mls	L	2.60	7.93	5.35	2.90	4.96
		S	2.66	7.29	5.20	2.96	5.39
	V-System	L	2.73	7.19	4.90	2.69	5.48
		S	2.56	7.27	5.40	3.14	5.45
100	NONE	L	2.74	7.91	4.80	2.61	5.31
		S	2.71	7.74	4.85	1.87	5.75
	3 x 100mls	L	2.66	8.31	4.55	3.17	5.01
		S	2.70	7.64	4.85	3.43	5.38
	V-System	L	2.63	7.64	4.45	4.43	4.87
		S	2.66	7.50	4.70	4.34	5.32
200	NONE	L	2.75	7.28	5.40	2.81	5.40
		S	2.51	7.04	5.60	2.95	6.31
	3 x 100mls	L	2.81	7.71	5.05	4.41	5.86
		S	2.61	7.73	5.15	3.94	5.36
	V-System	L	2.62	7.33	4.50	2.72	5.66
		S	2.65	7.44	4.75	3.11	5.71
400							
	NONE	L	2.60	8.14	4.75	2.49	5.24
		S	2.57	7.59	5.20	3.07	5.54
	3 x 100mls	L	2.71	8.33	4.65	3.18	5.09
		S	2.66	8.40	4.75	3.35	5.24
	V-System	L	2.67	7.98	4.70	3.00	5.21
		S	2.73	7.72	4.90	3.37	5.25

Appendix VI

Effect of irrigation regime and variety on shelf-life and fruit internal composition (Figures are a mean of 10 fruit from each of two replicates)

Week Number 19

Day regime mls/rounds	Sub Treatments (Night watering or V-System)	Variety (Liberto or Spectra)	Compression (mm)	Endpoint pH	% Soluble Solids	% Weight Loss (6 days)	% Dry Matter
50	NONE	L	3.02	7.39	5.15	3.11	6.12
		S	2.87	7.40	5.45	3.81	6.41
	3 x 100mls	L	3.36	7.27	5.15	4.37	5.70
		S	2.77	7.08	5.25	3.50	5.80
	V-System	L	2.91	7.39	5.05	3.25	5.64
		S	2.81	6.71	5.20	3.92	6.18
100	NONE	L	2.87	8.18	4.78	2.95	5.62
		S	2.86	7.26	5.00	3.49	5.85
	3 x 100mls	L	2.91	7.99	4.65	3.55	5.45
		S	2.62	7.89	4.88	3.15	5.75
	V-System	L	2.94	7.71	4.75	3.29	5.59
		S	2.88	7.10	4.90	3.45	5.63
200	NONE	L	2.85	7.29	5.40	3.07	6.47
		S	2.83	7.24	5.35	3.62	6.36
	3 x 100mls	L	3.04	7.65	4.80	3.94	5.56
		S	2.83	7.17	5.10	4.22	5.97
	V-System	L	3.01	7.46	4.78	3.83	5.50
		S	3.01	7.11	5.18	4.60	5.99
400	NONE	L	3.07	7.72	5.03	3.09	6.21
		S	2.80	7.13	5.30	2.94	6.13
	3 x 100mls	L	2.72	7.61	4.98	3.66	5.66
		S	2.77	7.54	4.98	3.71	5.55
	V-System	L	2.95	7.65	4.70	3.37	5.36
		S	2.83	7.18	5.15	3.70	5.66

Appendix VI

Effect of irrigation regime and variety on shelf-life and fruit internal composition (Figures are a mean of 10 fruit from each of two replicates)

Week Number 23

Day regime mls/round	Sub Treatments (Night watering or V-System)	Variety (Liberto or Spectra)	Compression (mm)	Endpoint pH	% Soluble Solids	% Weight Loss (6 days)	% Dry Matter
50	NONE	L	3.49	9.15	4.75	4.38	5.50
		S	3.45	8.54	4.80	5.50	5.66
	3 x 100mls	L	3.02	8.88	4.50	3.36	5.30
		S	3.13	8.34	4.78	5.07	5.65
	V-System	L	3.04	8.74	4.95	3.06	5.98
		S	3.20	8.42	5.10	3.42	5.86
100	NONE	L	2.98	8.59	4.50	3.71	5.42
		S	3.23	8.23	5.03	4.19	5.99
	3 x 100mls	L	3.27	8.80	4.43	2.88	5.32
		S	3.19	7.77	5.28	3.90	6.12
	V-System	L	2.99	8.58	5.33	2.18	6.31
		S	3.06	7.82	4.98	3.03	5.72
200	NONE	L	3.36	8.40	4.93	3.49	5.89
		S	3.36	7.84	5.25	4.80	6.13
	3 x 100mls	L	3.38	9.04	4.63	3.52	5.43
		S	3.16	8.57	4.93	4.17	5.94
	V-System	L	3.22	8.66	4.38	4.71	5.42
		S	3.15	8.41	4.80	4.09	5.69
400	NONE	L	2.96	7.66	5.80	2.47	7.07
		S	2.89	7.65	5.65	3.19	6.59
	3 x 100mls	L	3.06	8.50	4.78	3.81	5.63
		S	2.92	8.53	4.98	3.48	5.80
	V-System	L	3.12	8.75	4.60	3.23	5.65
		S	3.23	8.28	4.93	3.59	5.81

Appendix VI

Effect of irrigation regime and variety on shelf-life and fruit internal composition (Figures are a mean of 10 fruit from each of two replicates)

Week Number 27

Day regime mls/round	Sub Treatments (Night watering or V-System)	Variety (Liberto or Spectra)	Compression (mm)	Endpoint pH	% Soluble Solids	% Weight Loss (6 days)	% Dry Matter
50	NONE	L	2.98	8.84	4.73	2.91	6.04
		S	2.85	8.30	4.98	3.90	6.29
	3 x 100mls	L	2.95	8.93	4.63	2.62	5.91
		S	2.81	8.10	4.95	3.10	6.30
	V-System	L	2.80	8.92	4.83	2.82	6.14
		S	2.91	8.04	5.13	3.19	6.45
100	NONE	L	2.75	8.47	5.15	2.18	6.54
		S	2.64	8.04	5.28	2.99	6.71
	3 x 100mls	L	2.97	8.28	4.88	2.55	6.12
		S	2.75	7.68	5.10	3.76	6.37
	V-System	L	2.75	8.00	5.03	2.55	6.50
		S	2.77	7.34	5.33	3.47	6.79
200	NONE	L	3.00	8.65	4.78	3.82	6.08
		S	3.06	7.81	5.33	5.14	6.32
	3 x 100mls	L	2.98	8.79	4.63	2.74	5.91
		S	2.89	8.41	4.78	3.30	6.18
	V-System	L	2.83	8.76	4.68	2.80	6.00
		S	2.78	8.08	4.93	2.95	6.36
400	NONE	L	2.79	7.59	5.73	2.39	7.27
		S	3.27	7.52	5.85	4.50	7.01
	3 x 100mls	L	2.88	8.32	4.83	2.69	6.23
		S	2.91	7.82	5.13	3.36	6.45
	V-System	L	2.99	8.36	5.13	2.65	6.50
		S	2.81	8.34	5.03	3.31	6.17

Appendix VI

Effect of irrigation regime and variety on shelf-life and fruit internal composition (Figures are a mean of 10 fruit from each of two replicates)

Week Number 31

Day regime mls/round	Sub Treatments (Night watering or V-System)	Variety (Liberto or Spectra)	Compression (mm)	Endpoint pH	% Soluble Solids	% Weight Loss (6 days)	% Dry Matter
50	NONE	L	2.62	9.12	4.25	3.61	5.93
		S	2.65	8.57	4.50	4.16	6.14
	3 x 100mls	L	2.51	9.36	4.20	2.71	5.82
		S	2.58	8.38	4.55	3.49	6.15
	V-System	L	2.66	9.34	4.15	3.11	5.89
		S	2.75	8.71	4.35	3.68	6.08
100	NONE	L	2.62	8.55	4.63	3.04	5.90
		S	2.78	8.03	4.70	4.11	6.11
	3 x 100mls	L	2.67	9.12	4.38	3.58	5.76
		S	2.79	8.28	4.65	4.33	6.10
	V-System	L	2.77	8.60	4.53	3.81	6.09
		S	2.83	8.00	4.70	4.78	6.35
200	NONE	L	2.71	9.36	4.10	3.23	5.74
		S	2.79	8.60	4.40	4.14	5.90
	3 x 100mls	L	2.73	8.98	4.50	3.81	6.05
		S	2.76	8.98	4.13	3.42	5.75
	V-System	L	2.74	9.08	4.20	3.71	5.98
		S	2.76	8.55	4.45	3.92	6.24
400	NONE	L	2.66	8.48	4.80	4.14	6.39
		S	2.81	7.63	5.20	5.73	6.90
	3 x 100mls	L	2.64	8.86	4.30	3.12	6.17
		S	2.74	7.94	4.58	4.15	6.07
	V-System	L	2.63	8.97	4.40	3.38	6.03
		S	2.73	7.98	4.80	4.85	6.45

Appendix VI

Effect of irrigation regime and variety on shelf-life and fruit internal composition (Figures are a mean of 10 fruit from each of two replicates)

Week Number 35

Day regime mls/round	Sub Treatments (Night watering or V-System)	Variety (Liberto or Spectra)	Compression (mm)	Endpoint pH	% Soluble Solids	% Weight Loss (6 days)	% Dry Matter
50	NONE	L	3.13	8.99	3.93	6.13	5.32
		S	3.34	8.03	4.23	7.54	5.72
	3 x 100mls	L	3.29	8.76	3.80	4.80	5.49
		S	3.34	7.95	4.38	8.58	5.60
	V-System	L	3.11	8.41	3.93	5.34	5.36
		S	3.28	8.15	3.98	7.07	5.36
100	NONE	L	3.17	7.82	4.25	5.70	5.59
		S	3.20	7.73	4.43	6.97	5.68
	3 x 100mls	L	2.96	8.74	3.85	4.16	5.33
		S	3.18	8.43	4.03	7.07	5.49
	V-System	L	2.92	8.61	3.80	4.14	5.45
		S	3.17	7.77	4.30	5.97	5.76
200	NONE	L	3.04	8.91	3.65	5.19	5.31
		S	3.46	8.39	4.03	8.15	5.56
	3 x 100mls	L	2.81	8.84	3.80	4.14	5.18
		S	3.20	8.31	4.00	6.78	5.54
	V-System	L	3.00	8.66	3.75	4.86	5.31
		S	3.19	8.24	4.13	6.72	5.64
400	NONE	L	3.34	8.28	4.43	7.58	5.88
		S	3.27	8.26	4.25	6.83	5.52
	3 x 100mls	L	2.99	8.35	4.43	4.65	5.01
		S	3.10	8.26	4.00	6.48	5.57
	V-System	L	3.04	8.95	3.63	4.53	5.24
		S	3.20	8.23	4.05	6.35	5.52

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

PROPOSAL

1. TITLE OF PROJECT Contract No: PC/23c

IRRIGATION SYSTEMS FOR TOMATOES GROWN ON ROCKWOOL

2. BACKGROUND AND COMMERCIAL OBJECTIVE

The irrigation requirement of glasshouse crops is related to solar radiation and standard water figures for soil grown crops have been available for many years. The introduction of rockwool systems has meant that growers have had to develop new watering strategies as the small volumes of rockwool do not have the same water holding capacity as soil. Whilst the total quantity of water applied will be similar, the best way in which that quantity of water should be applied is not fully understood.

During the hot summers of 1989 and 1990 some growers have experienced problems with irrigation. This may simply have been due to the quantity of water their systems were capable of applying during peak mid-day periods, but the question of how the irrigation quantity should be determined and applied for best advantage remains unanswered. Further complications arise as the pH and conductivity in slabs has to be carefully controlled by watering and may apply constraints to watering frequency. Furthermore some growers apply water at night often to control conductivity. The benefits or otherwise of night watering other than for this reason have yet to be quantified.

3. POTENTIAL FINANCIAL BENEFIT TO THE INDUSTRY

It is difficult to quantify possible financial benefits but losses due to inadequate watering can be considerable particularly in relation to problems such as blossom end rot. Other aspects of fruit quality such as skin cracking may also be related to water regimes.

4. SCIENTIFIC/TECHNICAL TARGET OF THE WORK

To establish the most appropriate watering frequency for long season tomatoes grown in rockwool and to decide whether or not additional night watering is beneficial.

5. CLOSELY RELATED WORK

Work on energy optimisation in M block at Efford includes the relationship between humidity and water uptake. It is hoped that space might be set aside in F block to work on methods of

irrigation control probably using evaporative equipment which has yet to be designed.

Work on recirculating irrigation systems will be carried out at Stockbridge House EHS.

6. DESCRIPTION OF THE WORK

Treatments:

Main treatments: Main treatments will examine the irrigation frequency in relation to volume applied at each watering using 120% of the calculated daily requirement as the base value. The system will be triggered either by solarimeter or evapourimeter.

1. 50 mls per application

2. 100 mls per application

3. 200 mls per application

4. 400 mls per application

Sub treatments:

1. No night watering

2. 3 x 100ml night watering in addition to daily requirements

3. The 'V' growing system with 50% rockwool utilisation

Replication: 2 replicates using a total of 8 glasshouse compartments (8 x 81 m^2)

Variety: Liberto and Spectra

Records:

1. Monitoring to run-off

2. Assessment of fruit quality

3. Records of yield as standard to include total yield, class I yield by size grade, class II and waste.

4. Full records of achieved glasshouse temperature and humidity

Recording will continue until the end of September 1991.

Availabity of results

Results will be made available to growers through advisors and visits of tomato groups to Efford. A full report will be completed at the end of the trial. Interim results will be made available to H.D.C. throughout the season.

7. COMMENCEMENT DATE AND DURATION

1 October 1990 for 1 year.

8. STAFF RESPONSIBILITIES

Project leader: M J Leatherland, Efford EHS (Project deferred for 12 months, commenced November 1991; Project Leader Dr D J Hand)

9. LOCATION

Efford EHS

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 22.2.91