A REPORT TO THE HORTICULTURAL DEVELOPMENT COUNCIL
18 LAVANT STREET, PETERSFIELD, HANTS, GU32 3EW

SWEET PEPPERS: THE EFFECT OF FRUIT LOAD ON BLOSSOM-END ROT AND FRUIT QUALITY

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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Relevance to Growers and Practical Application

This project aimed to evaluate the effect of fruit load, fruit size at thinning and use of red 'anchor' fruit on sweet pepper fruit quality, particularly Blossom-end rot.

Sweet peppers, variety Mazurka, were grown at a density of 5.5 stems per m^2 from a January planting. Fruit were thinned to maintain loads of 3-4, 5-6 and 7-8 fruit per stem. There was also a variable load treatment, where loads were low initially and then increased. Fruit were either removed very early (<4 cm diameter) or left on the plant until they were larger before thinning.

The value of using red anchor fruit to maintain fruit loads was also investigated.

Early in the season yield of marketable fruit was reduced where fruit numbers were not reduced by thinning, but there were no significant effects of fruit load on total green fruit production for the season. More red fruit was produced at high fruit loads and this increased total marketable yield.

At the plant density used in this trial fruit load did not affect marketable fruit weight or size, but the use of anchor fruit increased the percentage of fruit over 90 mm diameter.

In the period until the end of June, fruit quality was highest where fruit were thinned to 3/4 per stem. At high fruit loads waste fruit was increased, due mainly to bad shape and Blossom-end rot.

The use of anchors also reduced Class I fruit, mainly due to poor skin finish. Downgraded fruit was generally Class II rather than waste. Blossom-end rot was most serious in May, June and July. The problem tended to be worse at high fruit loads.

The size at which fruit was thinned did not affect yield, size or fruit quality.

Action Points for Growers

Fruit does not need to be very small when it is thinned. Provided thinning is done regularly, leaving fruit to grow over 4 cm diameter does not reduce yield and has the benefit that poor quality fruit may be identified for removal.

The use of red anchor fruit to maintain fruit loads can increase total yield, but quality can be affected.

It is beneficial to thin fruit in the early part of the season to improve quality and marketable yield. In this trial 3-4 fruit until May gave the best results but optimum numbers will depend on variety, density, planting date and environmental conditions.

Experimental work is continuing to clarify this issue further.

Objective

To evaluate the effect of fruit load, fruit size at thinning and use of 'anchor' fruit on sweet pepper fruit quality, particularly Blossom-end rot (BER).

Introduction

Production of long season sweet pepper crops in hydroponics has increased in the UK over recent years. The most serious cause of marketable yield loss in the sweet pepper crop is Blossom-end rot. It is likely that the primary causes of BER involve calcium uptake and its distribution within the plant. Fruit load and growth rate, together with transpiration, are therefore likely to influence BER.

The pepper plant is very prone to developing flushes of fruit which lead to variable production and exacerbate the occurrence of Blossom-end rot. The removal of fruit to a pre-determined fruit load may decrease the occurrence of Blossom-end rot while also maintaining optimum fruit quality by reducing the stress on the plant caused by high fruit loads during flushing.

This project investigated 4 fruit loads, trimming either small or larger fruit and also assessed the value of red 'anchor' fruit in helping to control fruit load. The aim was to determine the optimum number of fruit per stem required to minimise the occurrence of BER whilst maintaining acceptable yield, fruit weight and quality.

The project also aimed to determine at what stage excess fruit should be removed and to establish whether the use of red anchor fruit was beneficial.

Materials and Methods

Cultural Details

Variety:	Mazurka (RZ)
Sowing Date:	24 November 1992
Planting Date:	20 January 1993
First Harvest:	11 March
Final Harvest:	2 November
Plant Population:	5.5 stems/m^2
Training:	2 leaders per plant
Pollination:	Bumble bees from January - June and September - November

Environment

Temperature:	23°C day, 21°C night, 27°C vent until crown fruit aborted then gradually reduced to 21°C day, 19°C night, 24°C vent with reduction in night temperature according to plant growth and fruit development.
Carbon Dioxide:	1000 vpm to end of April then 350 ppm.

Treatments

Fruit Load:	Low	=	3/4 fruit/stem
	Medium	=	5/6 fruit/stem
	High	=	7/8 fruit/stem
	Variable	=	Adjusted throughout the season

Thinning:	Remove small fruit, <4 cm diameter
	Remove large fruit, >4 cm diameter
Anchors:	With one additional red fruit
	Without red fruit

Experimental Design

The trial consisted of 16 treatments, each replicated 3 times, in a 4 fruit load x 2 thinnings x 2 anchors factorial structure. Two blocks of 12 double rows were available, each row was divided into 3 plots with 28 plants per plot.

Explanation of Statistical Terms

Throughout the report 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.

A number of common notations are also used to indicate the degree to which values are significantly different.

NS	=	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%).

Records and Assessments

Fruit yield in size grades (number and weight of fruit).
Fruit quality (% Class I, II, Waste).
Fruit with Blossom-end rot (Number & Weight).
Fruit shelf life assessments, monthly.
Fruit physical defects, monthly.
Daily monitoring of applied and slab pH and EC.
Full nutrient analysis of slab and applied solution weekly,
Fruit calcium analysis at harvest.

Shelf Life Conditions

Ten fruit per treatment were assessed at harvest and then kept under shelf life conditions of 20°C, 12 hours light, 65% RH for 6 days. Assessments were then repeated.

Fruit Quality

The following fruit quality factors were recorded:

Shape	Score 0-5, where 5 is blocky
Fine net cracking	Score 0-5, where 5 is severe
Longitudinal cracking	"
Calyx lifting	"
Shrivelling	Score 0-9, where 9 is severe
Shine	"
Ears	Number
% dry matter	
Sugar content	% soluble solids. Juice squeezed from fresh fruit onto hand held refractometer at the beginning and end of shelf life period.
Weight loss (%)	During the shelf life period
Firmness	Pressure (Newtons) required compress a fruit 1 cm at the beginning and end of the shelf life period. A high figure denotes a firmer fruit.

Results

Achieved Fruit Loads

Medium and high loads were not achieved consistently until June, due to the plants inability to carry this number of fruit, but numbers were kept as high as possible with no thinning unless targets were reached.

The variable loads treatment was maintained as follows:

Feb-Apr	Low
May-Jun	Medium
Jul-Aug	High
Sep-Nov	Medium

Fruit Yield

The crop was harvested green, except for the anchor fruit treatments where one red fruit per stem was used as necessary to help maintain fruit load.

Table 2 shows that the range of fruit load treatments did not affect the total weight of green fruit produced. Only in April were any significant differences recorded, when the low and variable treatments produced the highest weight of fruit. At that time the variable treatment was being trimming to 3/4 fruit per stem. 7/8 fruit per stem were not actually achieved during that period, but all fruit that set where left on the plant to keep load at the maximum level. This was too much for small plants at low light levels and much of the fruit produced was unmarketable.

The weight of red fruit picked did, however, vary between fruit load treatments (Table 3). In order to maintain medium and high fruit loads it was more necessary to use anchor fruit and therefore more red fruit was picked from those treatments.

On average the use of anchor fruit reduced green fruit yield by 1.79 kg/m^2 and increased red fruit yield by 3.54 kg/m^2, thereby giving an overall benefit of 1.75 kg/m^2 in total weight of fruit produced.

Fruit Size

Table 4 shows the average fruit weight of marketable fruit throughout the season.

The results show that at the density used in the trial (5.5 stems/m^2) with variety Mazurka, the number of fruit per stem did not significantly influence fruit weight of marketable fruit.

Fruit were heaviest in May and June and weight decreased considerably in all treatments from August onwards.

The size at which fruit was thinned had no effect on ultimate weight of those fruit remaining.

The use of anchor fruit significantly increased mean marketable fruit weight from May onwards. The ripe fruit increased average weight by 7 g on average, from 159 g to 166 g. The largest effects were seen in May and September to November.

14-15% of fruit in the trial fell into the extra large grade (over 90 mm diameter). There was no significant effect of fruit load except in August, when increasing fruit load significantly reduced the percentage of extra large fruit (Table 5).

The use of anchor fruit significantly increased the percentage of fruit over 90 mm diameter and there was a significant interaction between fruit load and the use of anchors. At low fruit loads, leaving anchors had a smaller effect on average size than it did at high fruit loads (Table 1, p14). This was due to the increased number of anchors that were required to maintain the high fruit load treatments.

Size of fruit when it was thinned had no effect on fruit size at harvest.

Table 1: The effect of anchor fruit and fruit load on fruit size (Average % Class I fruit over 90 mm diameter).

	With Anchors	Without Anchors
High	18.5	12.3
Medium	16.4	12.1
Low	15.5	12.8
Variable	16.2	12.5

Fruit Quality

In the period until the end of June fruit quality was reduced in the medium and high fruit load treatments. The load on the variable treatment was kept low over the initial period and the percentage Class I fruit was similar to the low fruit load treatment. Although the variable load was increased to medium in May, quality remained good, compared with the constant medium load treatment.

For the remainder of the season differences in quality between fruit load treatments were small and in October and November there was a decline in Percentage Class I fruit from all treatments (Table 9).

The use of anchor fruit tended to reduce the percentage of Class I fruit. This effect was particularly marked from August onwards.

The size of fruit at thinning did not affect the percentage of Class I fruit produced.

Fruit load and fruit size at thinning had no overall effect on the percentage of Class II fruit produced (Table 10). When quality fell in the high fruit load treatment the fruit tended to become waste, rather than be downgraded to Class II.

Use of anchor fruit significantly increased the percentage of Class II fruit. When use of anchors decreased fruit quality, defects tended to be minor, such as skin finish which caused the fruit to be downgraded rather than become unmarketable. Only in October did the use of anchors increase waste fruit production (Table 11).

Use of medium and high fruit loads increased waste fruit production. Differences were particularly marked in June.

Blossom-end rot

Blossom-end rot was a particular problem in May, June and July. Although differences were not statistically significant the results suggest that the problem was less serious at lower fruit loads (Table 12).

Generally the use of anchors increased levels of Blossom-end rot but this situation was reversed in May.

Size of fruit at thinning did not influence levels of Blossom-end rot.

Table 2: Marketable yield of green fruit (kg/m^2)

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct/ Nov	Total to end Season
Fruit Load									
High	1.43	2.65	2.55	2.98	4.48	3.32	3.63	2.55	23.58
Medium	1.32	2.90	2.60	2.95	4.59	3.25	3.64	2.58	23.82
Low	1.24	3.00	2.29	2.97	4.69	3.22	3.55	2.49	23.47
Variable	1.32	3.08	2.41	3.02	4.58	3.34	3.56	2.58	23.88
SED	0.076	0.125	0.121	0.116	0.096	0.067	0.098	0.103	0.283
LSD	-	0.27	-	-	-	-	-	-	-
Significance	NS	**	NS	NS	NS	NS	NS	NS	NS
Thinning									
Under 4cm	1.30	2.92	2.40	3.05	4.54	3.29	3.58	2.57	23.64
Over 4cm	1.36	2.90	2.52	2.91	4.63	3.28	3.61	2.53	23.73
SED	0.054	0.089	0.086	0.082	0.068	0.047	0.069	0.073	0.200
LSD	-	-	-	-	-	-	-	-	-
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS
Anchors									
With	1.29	2.81	2.40	3.05	4.27	3.24	3.23	2.49	22.79
Without	1.36	3.00	2.52	2.91	4.90	3.32	3.96	2.61	24.58
SED	0.054	0.089	0.086	0.082	0.068	0.047	0.069	0.073	0.200
LSD	-	0.19	-	-	0.3	-	0.14	-	0.4
Significance	NS	*	NS	NS	***	NS	***	NS	***

Table 3: Marketable yield of red fruit (kg/m^2)

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct/ Nov	Total to end Season
Fruit Load									
High	0	0.02	0.44	0.64	0.99	0.62	0.59	0.48	3.77
Medium	0	0.02	0.37	0.75	1.11	0.60	0.59	0.60	4.04
Low	0	0.01	0.10	0.61	1.02	0.50	0.53	0.61	3.37
Variable	0	0.03	0.17	0.70	1.08	0.60	0.57	0.54	3.68
SED	0.001	0.009	0.034	0.069	1.060	0.050	0.040	0.060	0.125
LSD	-	-	0.06	-	-	-	-	-	0.26
Significance	NS	NS	***	NS	NS	NS	NS	NS	***
Thinning									
Under 4cm	0	0.03	0.27	0.69	0.99	0.59	0.55	0.53	3.63
Over 4cm	0	0.02	0.27	0.66	1.11	0.56	0.59	0.59	3.80
SED	0.001	0.006	0.024	0.049	0.042	0.036	0.028	0.043	0.089
LSD	-	-	-	-	1.6	-	-	-	-
Significance	NS	NS	NS	NS	**	NS	NS	NS	NS
Anchors									
With	0	0.03	0.50	1.05	1.33	0.82	0.91	0.85	5.49
Without	0	0.02	0.04	0.30	0.77	0.34	0.23	0.26	1.95
SED	0.001	0.006	0.024	0.049	0.042	0.036	0.028	0.043	0.089
LSD	-	-	0.04	0.1	2.7	0.08	0.06	0.09	0.2
Significance	NS	NS	***	***	***	***	***	***	***

Table 4: Mean weight of marketable fruit (g)

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct/ Nov	Mean
Fruit Load									
High	150	170	199	193	172	152	146	138	163
Medium	142	165	197	193	173	153	146	137	162
Low	148	171	194	195	170	153	146	138	163
Variable	148	173	198	193	169	153	148	139	164
SED	3.52	2.60	2.14	1.52	1.42	1.00	1.39	1.94	0.69
LSD	-	5	-	-	3	-	-	-	-
Significance	NS	*	NS	NS	*	NS	NS	NS	NS
Thinning									
Under 4cm	146	170	198	194	172	152	146	138	163
Over 4cm	148	169	197	193	170	152	147	138	163
SED	2.49	1.84	1.52	1.07	1.01	0.71	0.98	1.37	0.48
LSD	-	-	-	-	-	-	-	-	-
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS
Anchors									
With	147	168	202	195	174	156	152	144	166
Without	147	171	192	191	168	149	141	132	159
SED	2.49	1.84	1.52	1.07	1.01	0.71	0.98	1.37	0.49
LSD	-	-	3	2	2	2	2	3	1
Significance	NS	NS	***	***	***	***	***	***	***

Table 5: Extra large fruit (% Class I over 90 mm diam)

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct/ Nov	Mean
Fruit Load									
High	6.9	10.1	27.6	30.9	20.2	7.4	6.3	5.5	15.4
Medium	6.6	7.0	26.6	28.2	19.4	7.9	5.9	5.2	14.2
Low	6.3	8.3	23.6	28.7	18.4	9.7	5.6	5.8	14.2
Variable	7.2	10.3	26.1	27.2	17.8	8.4	6.2	5.3	14.3
SED	1.45	1.58	2.51	1.75	1.36	0.88	1.14	0.95	0.73
LSD	-	-	-	-	-	1.8	-	-	-
Significance	NS	NS	NS	NS	NS	* 8%	NS	NS	NS
Thinning									
Under 4cm	5.6	9.2	27.4	28.8	19.0	8.9	6.1	5.8	14.8
Over 4cm	7.9	8.6	24.5	28.7	18.9	7.8	5.9	5.1	14.3
SED	1.03	1.12	1.78	1.24	0.96	0.63	0.81	0.67	0.51
LSD	2.1	-	-	-	-	-	-	-	-
Significance	*	NS	NS	NS	NS	NS	NS	NS	NS
Anchors									
With	5.8	8.3	30.9	28.8	21.2	11.4	7.8	8.4	16.6
Without	7.7	9.6	21.1	28.7	16.7	5.3	4.2	2.5	12.4
SED	1.03	1.12	1.78	1.24	0.96	0.63	0.81	0.67	0.51
LSD	-	-	3.7	-	2.0	1.3	1.7	1.4	1.0
Significance	NS	NS	***	NS	***	***	***	***	***

Table 6: Large fruit (% Class I 80-90 mm diam)

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct/ Nov	Mean
Fruit Load									
High	45.7	46.8	45.9	50.3	50.3	42.4	33.3	29.3	43.8
Medium	38.1	43.5	48.6	49.1	50.9	42.2	32.6	25.9	42.6
Low	44.2	47.9	49.2	49.8	50.6	38.7	32.8	28.6	43.6
Variable	46.1	49.5	49.0	51.1	52.4	42.5	33.4	28.7	45.0
SED	3.31	2.69	2.34	2.08	1.64	1.31	1.54	1.89	0.78
LSD	-	-	-	-	-	2.7	-	-	1.6
Significance	NS	NS	NS	NS	NS	*	NS	NS	*
Thinning									
Under 4cm	43.2	48.9	47.9	49.7	51.8	41.9	32.9	28.0	44.0
Over 4cm	43.9	45.0	48.4	50.4	50.3	41.0	33.2	28.2	43.5
SED	2.34	1.90	1.66	1.47	1.16	0.92	1.09	1.34	0.55
LSD	-	3.9	-	-	-	-	-	-	-
Significance	NS	*	NS	NS	NS	NS	NS	NS	NS
Anchors									
With	43.3	46.5	46.7	51.1	51.2	43.1	37.9	33.8	45.2
Without	43.8	47.3	49.6	49.0	50.9	39.8	28.2	22.5	42.3
SED	2.34	1.90	1.66	1.47	1.16	0.92	1.09	1.34	0.55
LSD	-	-	-	-	-	1.9	2.2	2.8	1.1
Significance	NS	NS	NS	NS	NS	**	***	***	***

Table 7: Medium fruit (% Class I 70-80 mm diam)

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct/ Nov	Mean
Fruit Load									
High	39.2	39.5	25.9	18.2	27.8	47.5	55.0	56.6	37.4
Medium	43.4	44.0	24.0	21.7	28.4	46.4	57.0	60.7	39.4
Low	42.0	40.5	26.5	20.7	29.3	47.5	56.6	57.0	38.7
Variable	38.2	37.1	24.2	20.8	28.7	46.6	56.1	58.3	37.7
SED	3.58	3.02	2.14	2.02	1.53	1.05	2.10	2.06	1.01
LSD	-	-	-	-	-	-	-	-	-
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS
Thinning									
Under 4cm	42.7	38.1	24.0	20.8	28.0	46.2	56.3	57.7	37.9
Over 4cm	38.7	42.4	26.3	19.9	29.1	47.8	56.0	58.6	38.7
SED	2.53	2.13	1.52	1.43	1.08	0.74	1.49	1.45	0.71
LSD	-	4.4	-	-	-	-	-	-	-
Significance	NS	*	NS	NS	NS	NS	NS	NS	NS
Anchors									
With	41.0	41.1	21.6	18.5	26.0	42.7	50.4	49.7	34.8
Without	40.5	39.5	28.7	22.3	31.1	51.3	61.9	66.6	41.8
SED	2.53	2.13	1.52	1.43	1.08	0.74	1.49	1.45	0.71
LSD	-	-	3.1	-	2.2	1.5	3.1	3.0	1.5
Significance	NS	NS	***	NS	***	***	**	***	***

Table 8: Small fruit (% Class I 50-70 mm diam)

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct/ Nov	Mean
Fruit Load									
High	8.1	3.5	0.7	0.6	1.7	2.8	5.4	8.7	3.4
Medium	11.9	5.5	0.8	1.0	1.3	3.5	4.5	8.2	3.8
Low	7.5	3.3	0.7	0.8	1.7	4.1	5.1	8.6	3.4
Variable	8.4	3.1	0.7	0.9	1.1	2.6	4.3	7.6	3.0
SED	1.44	0.74	0.30	0.35	0.37	0.60	0.66	1.00	0.25
LSD	3.0	1.5	-	-	-	1.2	-	-	0.5
Significance	*	**	NS	NS	NS	* 6%	NS	NS	*
Thinning									
Under 4cm	8.5	3.8	0.7	0.6	1.3	3.1	4.7	8.5	3.3
Over 4cm	9.5	4.0	0.8	1.0	1.7	3.4	5.0	8.1	3.6
SED	1.02	0.52	0.21	0.25	0.26	0.42	0.47	0.71	0.17
LSD	-	-	-	-	-	-	-	-	-
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS
Anchors									
With	9.9	4.0	0.8	0.7	1.6	2.9	3.9	8.2	3.3
Without	8.1	3.7	0.7	0.9	1.4	3.6	5.7	8.4	3.5
SED	1.02	0.52	0.21	0.25	0.26	0.42	0.47	0.71	0.17
LSD	2.1	-	-	-	-	-	1.0	-	-
Significance	* 8%	NS	NS	NS	NS	NS	***	NS	NS

Table 9: Percentage Class I (by weight)

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct/ Nov	Mean
Fruit Load									
High	89.6	86.7	74.5	77.5	78.1	77.1	70.8	67.3	76.8
Medium	88.7	87.8	75.4	77.5	75.6	76.6	71.6	66.3	76.6
Low	89.9	88.9	79.2	82.1	79.5	80.3	71.7	65.9	79.0
Variable	90.4	89.1	78.7	80.9	77.8	76.8	72.2	67.2	78.3
SED	1.66	1.58	1.98	1.69	1.14	1.85	1.42	1.66	0.72
LSD	-	-	4.1	3.5	2.4	-	-	-	1.5
Significance	NS	NS	* 6%	*	*	NS	NS	NS	**
Thinning									
Under 4cm	89.9	88.5	76.5	79.5	77.7	79.0	71.3	66.8	77.8
Over 4cm	89.4	87.7	77.5	79.5	77.7	76.4	71.8	66.6	77.5
SED	1.18	1.12	1.40	1.19	0.81	1.31	1.00	1.17	0.51
LSD	-	-	-	-	-	-	-	-	-
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS
Anchors									
With	90.1	87.4	77.7	77.8	77.7	75.9	70.0	63.0	76.7
Without	89.1	88.9	76.2	81.2	77.7	79.5	73.1	70.4	78.7
SED	1.18	1.12	1.40	1.19	0.81	1.31	1.00	1.17	0.51
LSD	-	-	-	2.5	-	2.7	2.1	2.4	1.1
Significance	NS	NS	NS	**	NS	**	**	***	***

Table 10: Percentage Class II (by weight)

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct/ Nov	Mean
Fruit Load									
High	5.3	7.0	11.6	12.6	11.7	16.0	23.8	27.0	14.9
Medium	7.2	6.8	11.3	11.8	13.9	15.5	22.6	27.3	15.0
Low	5.8	5.5	9.8	10.9	11.3	13.8	23.0	27.9	14.0
Variable	6.1	5.4	9.9	10.4	12.4	15.4	22.3	27.0	14.1
SED	1.10	1.10	1.00	1.23	0.95	1.80	1.27	1.80	0.51
LSD	-	-	-	-	2.0	-	-	-	-
Significance	NS	NS	NS	NS	* 6%	NS	NS	NS	NS
Thinning									
Under 4cm	5.7	5.7	10.1	12.1	12.2	14.0	23.3	27.2	14.3
Over 4cm	6.6	6.6	11.2	10.8	12.4	16.3	22.5	27.4	14.7
SED	0.78	0.78	0.71	0.87	0.67	1.28	0.90	1.27	0.36
LSD	-	-	-	-	-	-	-	-	-
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS
Anchors									
With	6.0	6.9	10.9	12.5	12.0	16.5	24.3	30.0	15.3
Without	6.2	5.5	10.4	10.3	12.6	13.8	21.6	24.6	13.7
SED	0.78	0.78	0.71	0.87	0.67	1.28	0.90	1.27	0.36
LSD	-	-	-	1.8	-	2.6	1.8	2.6	0.7
Significance	NS	NS	NS	*	NS	*	**	***	***

Table 11: Percentage waste (by weight)

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct/ Nov	Mean
Fruit Load									
High	5.1	6.3	13.9	9.9	10.2	6.9	5.5	5.7	8.3
Medium	4.1	5.4	13.2	10.8	10.6	7.9	5.8	6.4	8.4
Low	4.3	5.6	11.0	7.0	9.2	5.9	5.3	6.3	7.1
Variable	3.5	5.5	11.4	8.7	9.8	7.8	5.5	5.8	7.6
SED	1.06	0.80	1.56	1.35	0.74	0.83	0.60	1.00	0.43
LSD	-	-	-	2.8	-	1.7	-	-	0.9
Significance	NS	NS	NS	*	NS	* 8%	NS	NS	*
Thinning									
Under 4cm	4.4	5.7	13.5	8.5	10.1	7.0	5.4	6.0	7.9
Over 4cm	4.1	5.6	11.3	9.7	9.9	7.3	5.7	6.1	7.8
SED	0.75	0.57	1.10	0.95	0.52	0.59	0.42	0.71	0.30
LSD	-	-	2.3	-	-	-	-	-	-
Significance	NS	NS	* 6%	NS	NS	NS	NS	NS	NS
Anchors									
With	3.9	5.8	11.4	9.7	10.3	7.6	5.7	7.1	8.1
Without	4.7	5.6	13.4	8.5	9.7	6.7	5.4	5.0	7.6
SED	0.75	0.57	1.10	0.95	0.52	0.59	0.42	0.71	0.30
LSD	-	-	-	-	-	-	-	1.5	-
Significance	NS	NS	NS	NS	NS	NS	NS	**	NS

Table 12: Percentage Blossom-end rot (by number)

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct/ Nov	Mean
Fruit Load									
High	2.9	4.7	10.6	8.6	8.4	4.9	2.8	1.2	5.5
Medium	1.8	4.7	10.5	7.9	8.3	6.3	3.3	1.2	5.6
Low	2.1	4.8	8.2	5.5	7.3	4.0	2.4	1.2	4.6
Variable	1.7	4.8	9.1	6.7	8.1	5.8	2.9	1.1	5.2
SED	0.67	0.69	1.33	1.27	0.71	0.79	0.41	0.39	0.35
LSD	-	-	-	-	-	1.6	-	-	0.7
Significance	NS	NS	NS	NS	NS	*	NS	NS	*
Thinning									
Under 4cm	1.9	4.7	10.4	6.9	7.9	5.3	2.8	1.0	5.2
Over 4cm	2.3	4.8	8.8	7.4	8.1	5.1	2.9	1.4	5.2
SED	0.47	0.49	0.94	0.90	0.50	0.56	0.29	0.27	0.25
LSD	-	-	-	-	-	-	-	-	-
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS
Anchors									
With	1.7	5.0	8.7	7.5	8.3	5.9	3.2	1.5	5.5
Without	2.5	4.5	10.5	6.8	7.7	4.6	2.5	0.9	5.0
SED	0.47	0.49	0.94	0.90	0.50	0.56	0.29	0.27	0.25
LSD	-	-	1.9	-	-	1.2	0.6	0.6	-
Significance	NS	NS	* 6%	NS	NS	*	*	*	NS

Fruit Calcium Levels

The calcium content of green fruit at harvest was recorded monthly. Levels varied considerably but the average figures are shown in Table 13.

Table 13: Total Calcium (% of DM).

Fruit Load	Average	May
Low	0.105	0.096
Medium	0.102	0.090
High	0.098	0.082
Variable	0.101	0.096

The figures suggest that overall, fruit calcium levels are likely to be lower at high fruit loads. In May, when BER was most severe fruit calcium levels were lower in the treatments where there was more fruit damage.

Fruit Defects

Fruit Shape

Of the fruit that were marketable there was no consistent difference in shape between size at thinning or anchor treatments (Appendix II: Fig 1 a-c). From March to July shape was more blocky from the low fruit load treatments, than the high. There were more unmarketable fruit due to poor shape at the high load treatment.

Fine Net Cracking

Levels of fine net cracking were generally low, except in July. At this time the low fruit load treatment was affected the most and the same trend was recorded in September and October. Earlier in the year, however, the high fruit load treatment was affected as much as, or more than the low fruit load treatment.

Although only green fruit were sampled for examination, leaving red anchors seemed to reduced fine net cracking in the period up to July. Thereafter the situation was reversed (Fig 2 a-c).

Fruit size at thinning did not affect fine net cracking.

% Dry Matter

There was no clear relationship between fruit load or use of anchors and dry matter content. Where fruit were removed at less than 4 cm diameter fruit dry matter was generally slightly higher (Fig 3 a-b).

Other Factors

Levels of longitudinal cracking, calyx lifting and 'ears' were low throughout the season and there were no consistent differences between treatments were recorded (Figures 4 to 6).

Shelf Life

Shrivelling

In terms of shelf life, fruit quality was lowest in March and June. There was no relationship between shrivelling and fruit load or use of anchors. Where fruit had been thinned at less the 4 cm diameter shrivelling was generally slightly worse after 6 days under shelf life conditions (Appendix II: Fig 7 a-c).

Shine

In June, July and August fruit from the high fruit load treatment was less shiny at harvest, and at most of the monthly assessments this treatment tended to become dullest during storage (Fig 8 a-b). There was no consistent effect of size at thinning or use of anchors on fruit shine.

Firmness

In October harvested fruit was very firm from the low fruit load treatments compared with the medium and high but otherwise differences at harvest were small. Fruit from plants with anchors also tended to be firmer at harvest (Fig 9). Fruit firmness after 6 days storage declined as the season progressed. At the beginning of the year high fruit loads decreased firmness after storage. There was no evidence that use of anchors or fruit size at thinning had any consistent effect.

Sugar Content

Although there were differences in fruit sugar levels at harvest between fruit load treatments these differences were inconsistent. Use of anchors tended to decrease sugar levels early in the season (Mar-Jul) and increase them from August onwards (Fig 10). Size at thinning did not influence sugar content.

Discussion

Fruit Load

High fruit loads (7/8 fruit per stem) were difficult to achieve, particularly in the early part of the season when light levels were low and plants were relatively small. In this period no fruit were removed from the plant in order to achieve the maximum load that the plant would carry. This led to problems with flushing which the trial aimed to avoid. When the load was high quality was poor and in some months size was reduced, at the same time flowers were aborting. Hence when the fruit was picked another flush set and the cycle was repeated.

The low and medium loads were easier to control and flushing was avoided.

The variable load treatment aimed to adjust fruit load according to the season and stage of growth. This treatment gave good results in terms of both yield and fruit quality and could be improved further with increased knowledge and experience.

In this trial marketable fruit size was not influenced significantly by increasing fruit load. The density (5.5 stems/m^2) was lower than is used by some growers and at a higher density one could expect greater effects with increased competition between plants. The variety, Mazurka, was a standard commercial variety but is not particularly large fruited. With a large fruited variety effects would probably be more pronounced.

At low fruit loads any fruit defects tended to be minor, such as skin finish, and poor fruit were therefore downgraded into Class II. At higher fruit loads fruit defects tended to be more severe, such as poor shape or Blossom-end rot and fruit therefore became unmarketable.

One reason for an increased percentage of unmarketable fruit at medium and high fruit loads was that at low fruit loads all poor fruit was removed to maintain the low load. Particularly early in the season it was necessary to leave poor quality fruit on the plant at the medium and high fruit load treatment.

If, by leaving a certain amount of poor fruit on the plant a maximum yield of good quality, well sized fruit is achieved this is not necessarily a problem. Despite increased waste, yield was not reduced at the high fruit load.

Low fruit loads produced the best yields of Class I fruit early in the season but showed no benefits from May onwards. At the end of the season skin finish tended to be poor where load was low.

Overall, although the effects on fruit size were not as expected, the results show that there are benefits in reducing fruit load in the early part of the season. This helps to develop a balanced plant which will help for the rest of the season. Thereafter thinning fruit to less than 5/6 fruit gave no benefit and is likely to reduce potential yield.

More clarification is needed on when it is possible to use more than 5/6 fruit. This is likely to depend on season, variety and density.

At high fruit loads Blossom-end rot was more serious than at low fruit loads. Flushes of growth are likely to aggravate the problem and although very variable, calcium levels were generally lower with increasing load. In the variable treatment, where fruit load was controlled and flushing minimised BER was serious in August.

The results suggest that sink size (fruit load) is more influential in determining fruit calcium level than fruit growth rate as calcium levels were higher at low loads where fruit generally developed faster. This issue is complicated by the variable development rates caused by fruit flushing and more research is required into this complicated issue.

Fruit Size at Thinning

Overall there was very little difference in yield or fruit quality where fruit were removed small or allowed to remain on the plant longer.

Leaving them larger has the benefit that it is clearer to see which fruit are likely to be poor quality and to remove them in preference to good fruit.

In this trial removing fruit at less than 4 cm seemed to increase the dry matter content of the remaining fruit at harvest, but yield was no higher.

The results therefore suggest that it is not vital to remove fruit as small as possible and that there can be quality benefits in leaving them slightly larger. Thinning was carried out every week so fruit were therefore removed frequently, thinning larger fruit less frequently is likely to lead to flushing.

Anchors

In this trial the effect of using anchors was related to the fruit load treatments, as anchors were required more frequently to help maintain high loads.

The use of anchors decreased green fruit yield but increased overall yield and therefore should be beneficial. To help maintain fruit load the results suggest it is better to leave an anchor fruit than to leave poor quality green fruit at the top of the plant, although the quality of anchor fruit was not always good, particularly from August onwards.

There was no difference in waste fruit production but more Class II from the treatments where anchors were used. Skin finish was sometimes poor on the red fruit but detailed quality assessments showed that where red fruit were left on the plant early in the season russetting on the green fruit was reduced, possibly by causing more even fruit development rate. From August onwards, however, use of anchors seemed to make the problem worse however.

Overall, the use of anchors selectively as required seemed to offer benefits, particularly in the first half of the season.

Conclusions

1. Thinning fruit at 4 cm diameter or over did not reduce marketable yield.

2. The use of red anchor fruit decreased green fruit yield but increased total marketable yield.

3. The use of red anchor fruit increased average fruit weight.

4. At high fruit loads yield of red fruit was higher.

5. In this trial increasing fruit load did not influence marketable fruit weight.

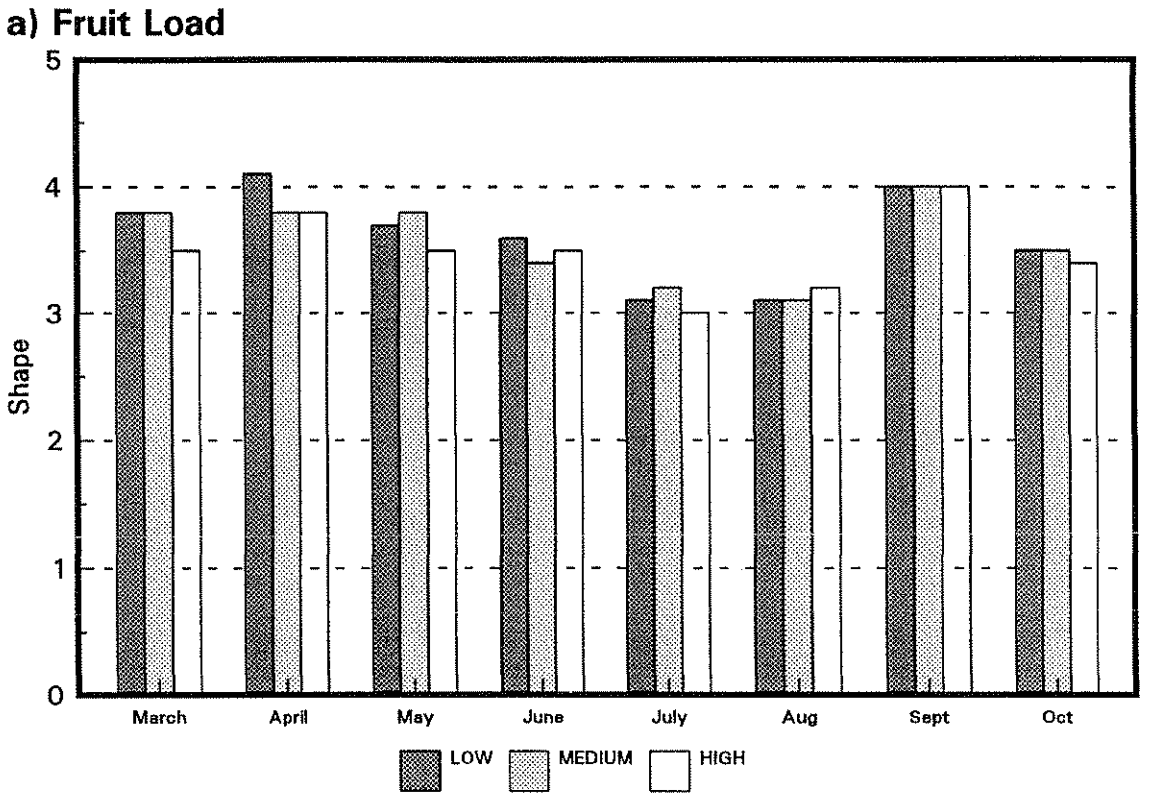
6. From March to May high fruit loads were difficult to maintain.

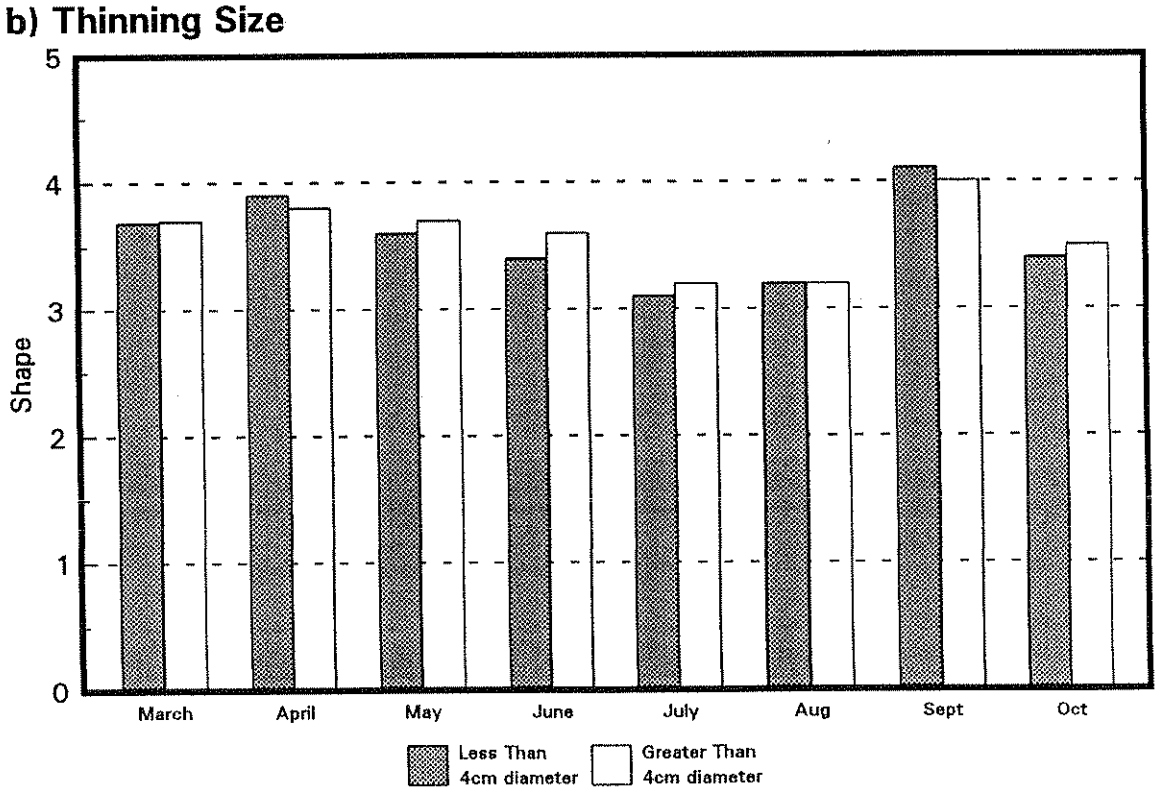
7. Use of maximum fruit loads early in the season led to fruit flushing, and reduced quality.

8. Maintaining low fruit loads tended to reduce the occurrence of Blossom-end rot.

APPENDIX I: FRUIT DEFECTS

Fig 1: Fruit shape (0 = pointed, 5 = blocky).





c) Anchors

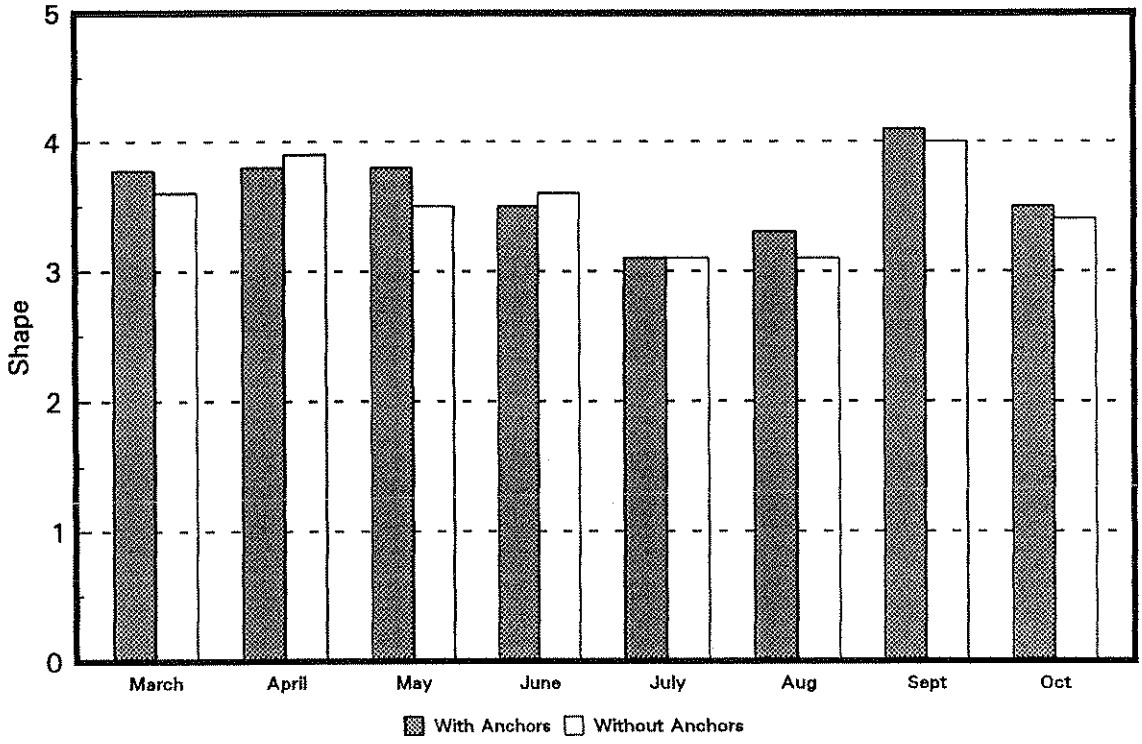
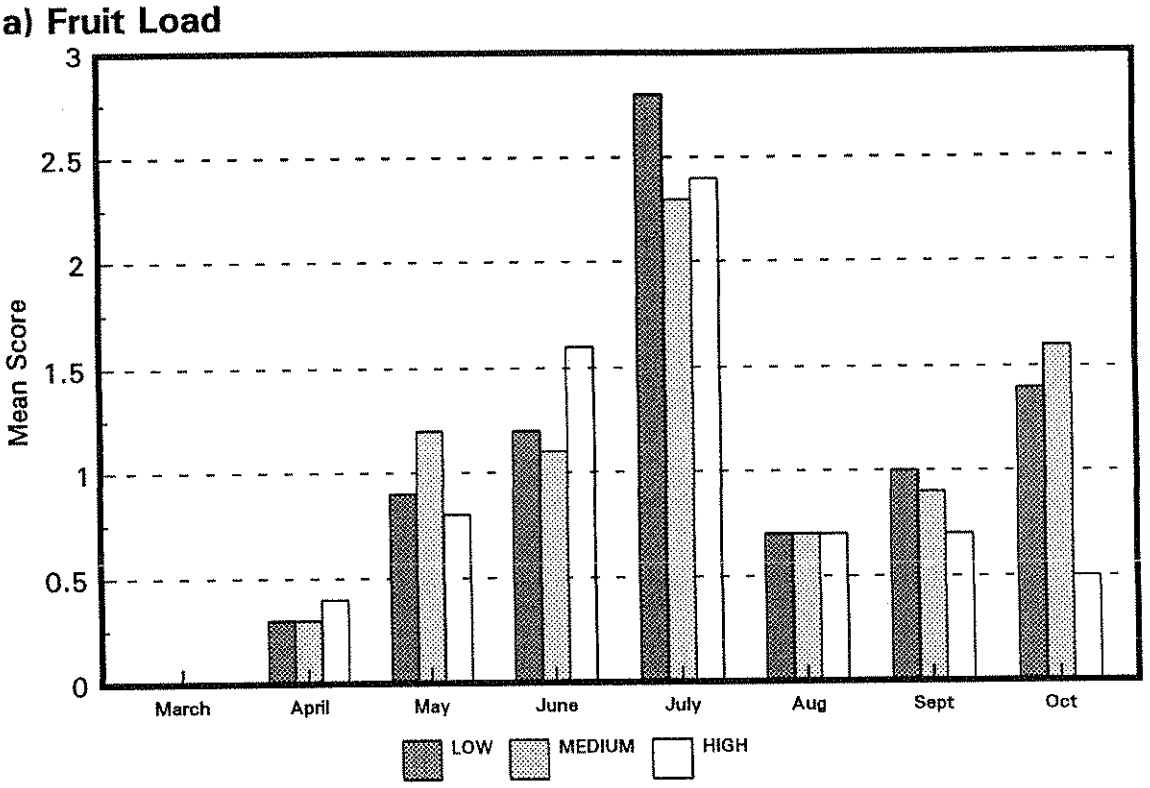
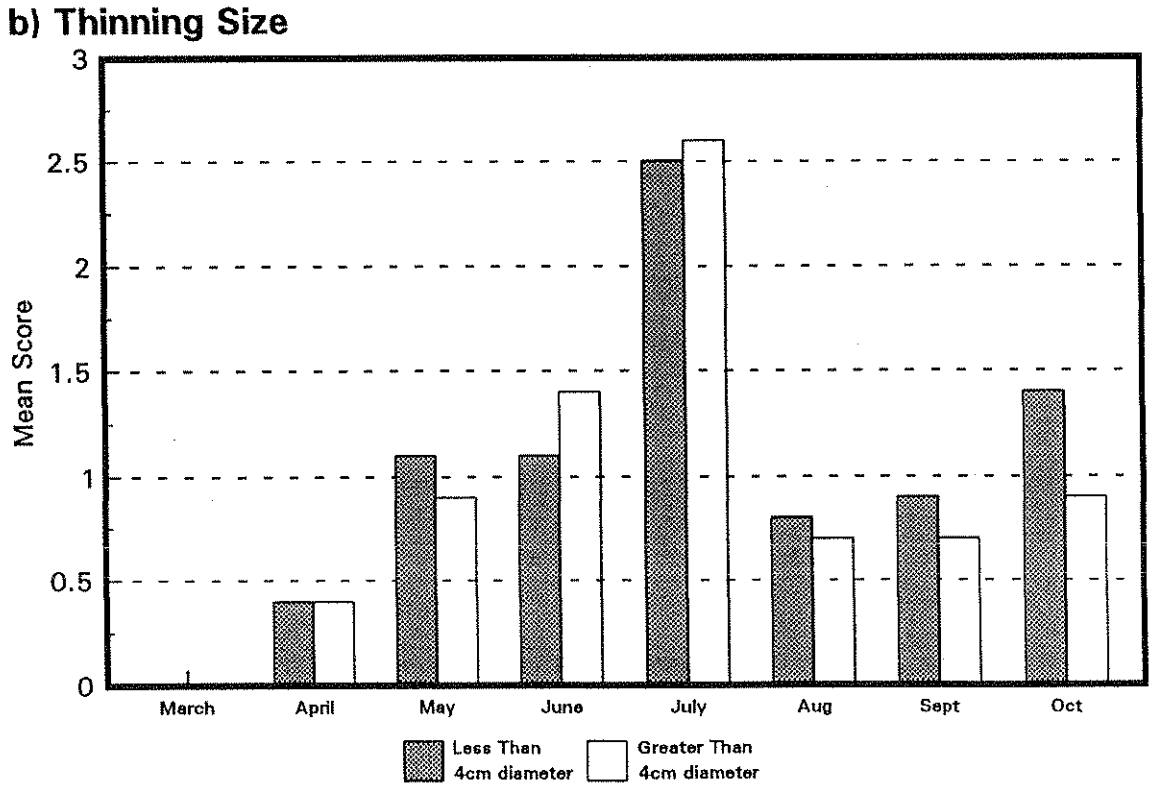

5
4
3
2
1
0
Shape
March
April
May
June
July
Aug
Sept
Oct
With Anchors
Without Anchors

Fig 2: Fine net cracking (0 = none, 9 = severe).





c) Anchors

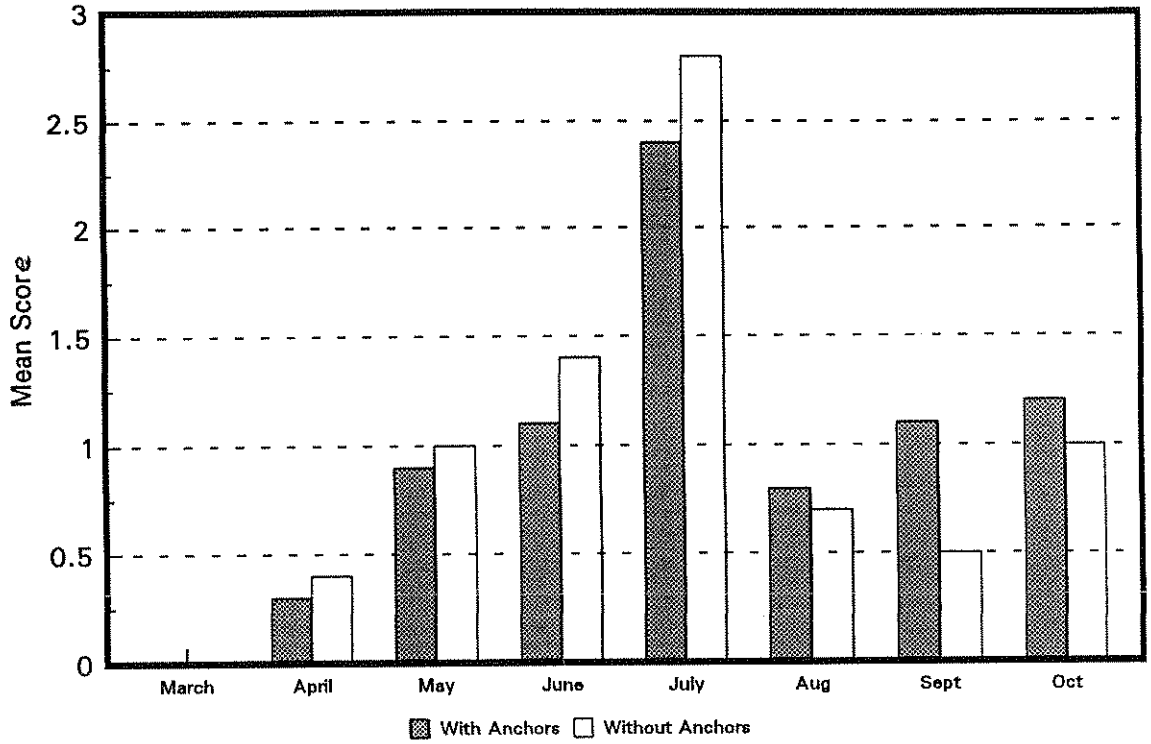
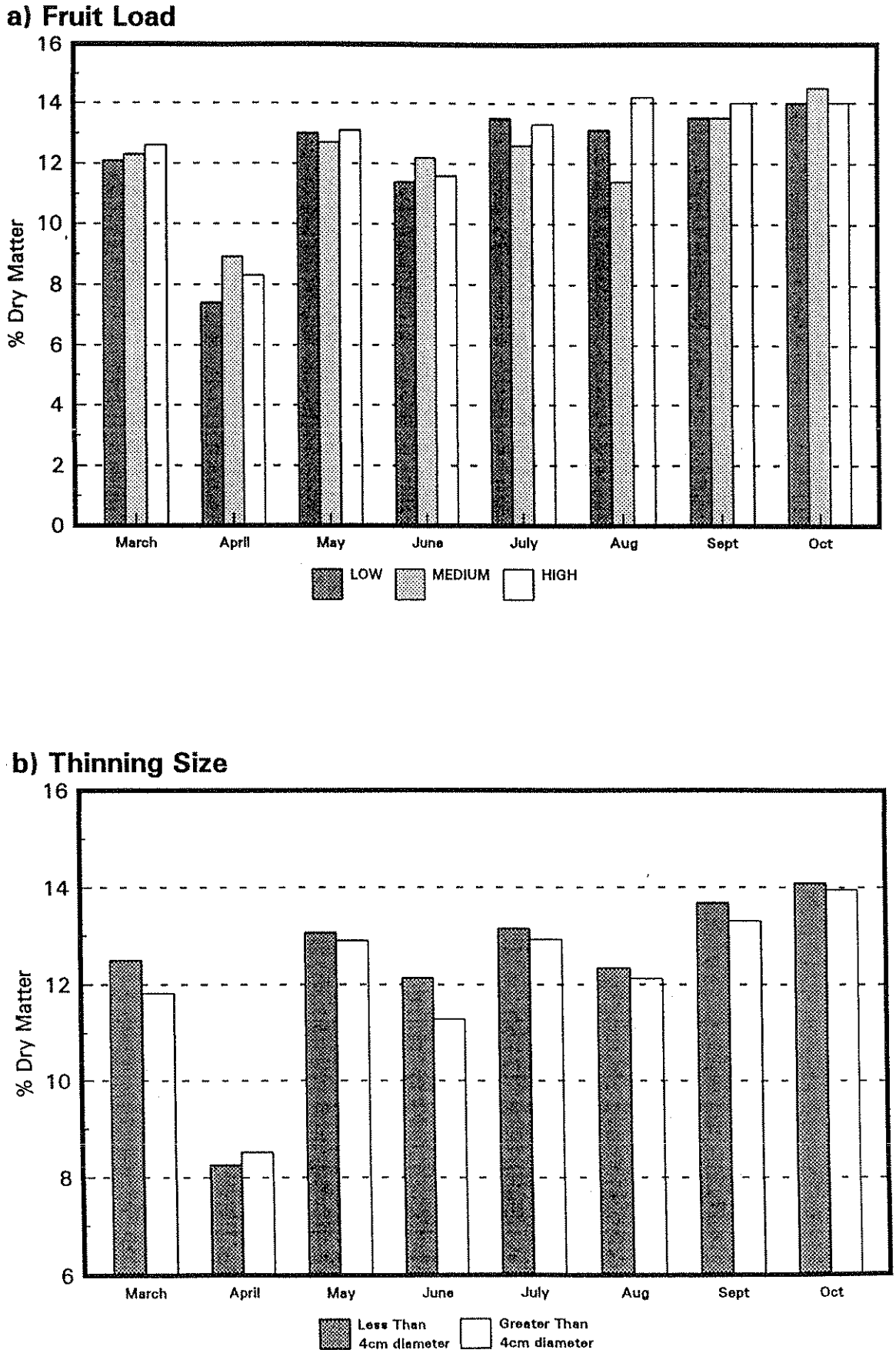

3
2.5
2
1.5
1
0.5
0
Mean Score
March
April
May
June
July
Aug
Sept
Oct
With Anchors
Without Anchors

Fig 3: Fruit dry matter (%).



c) Anchors

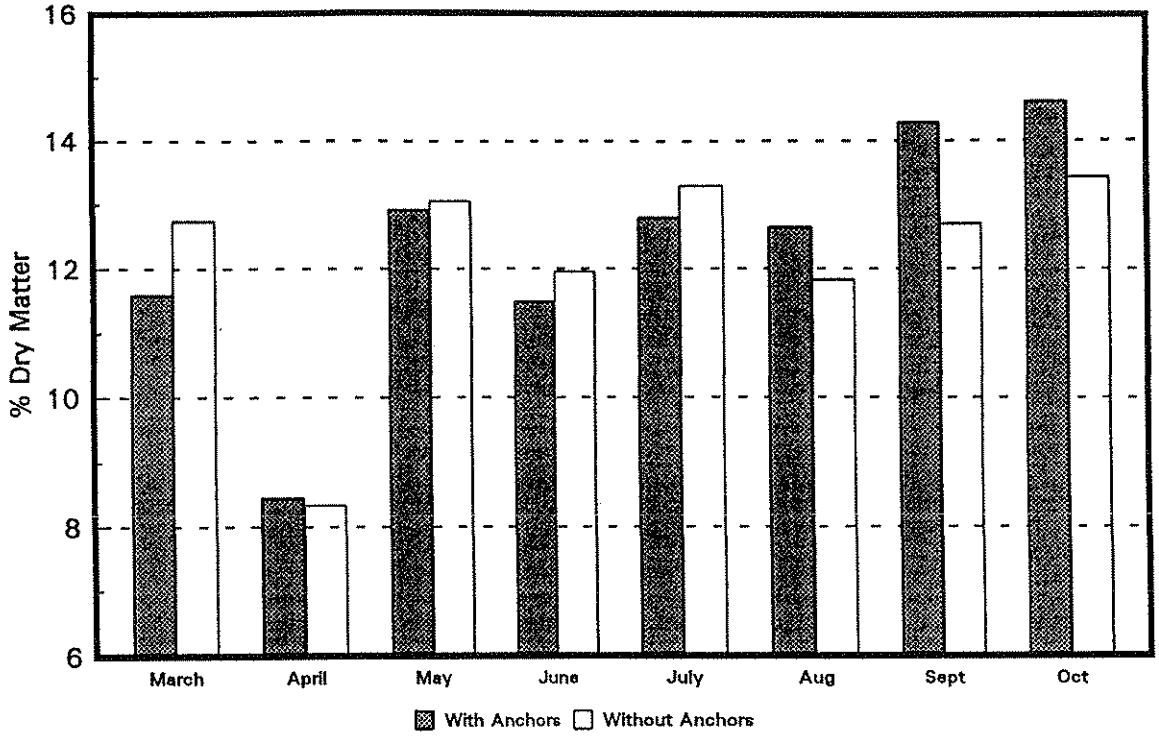
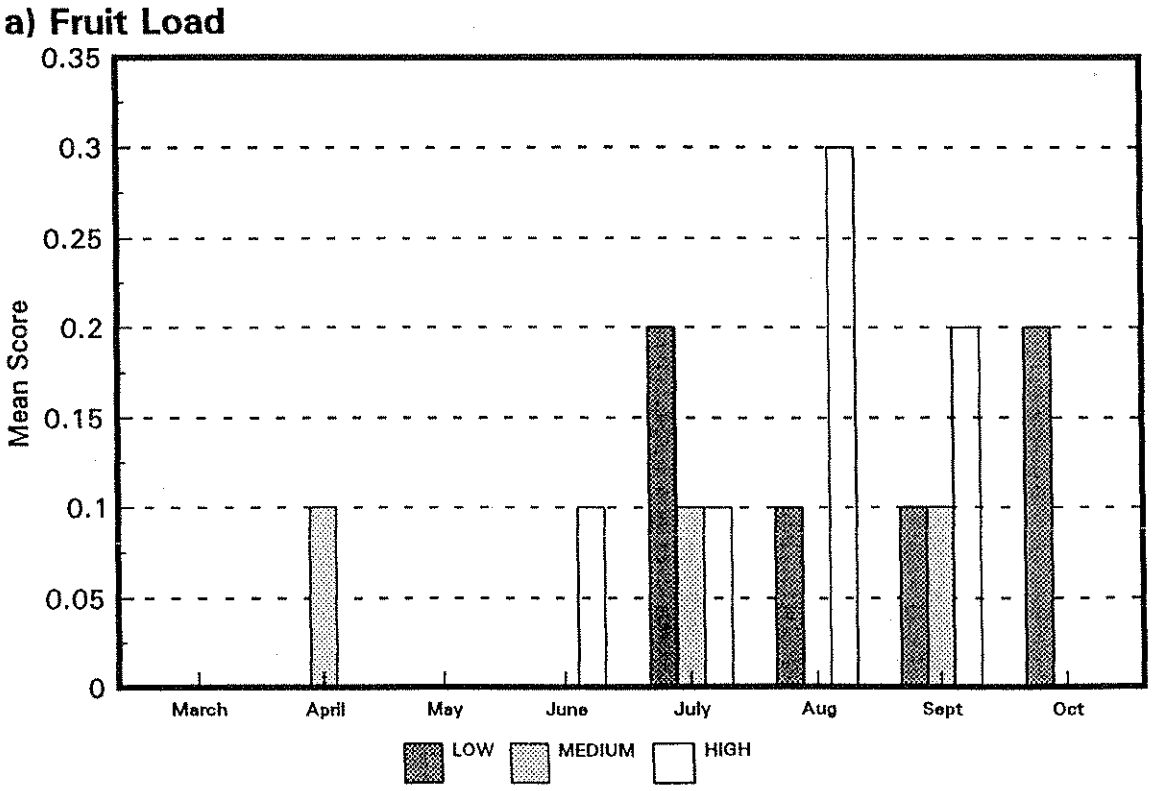
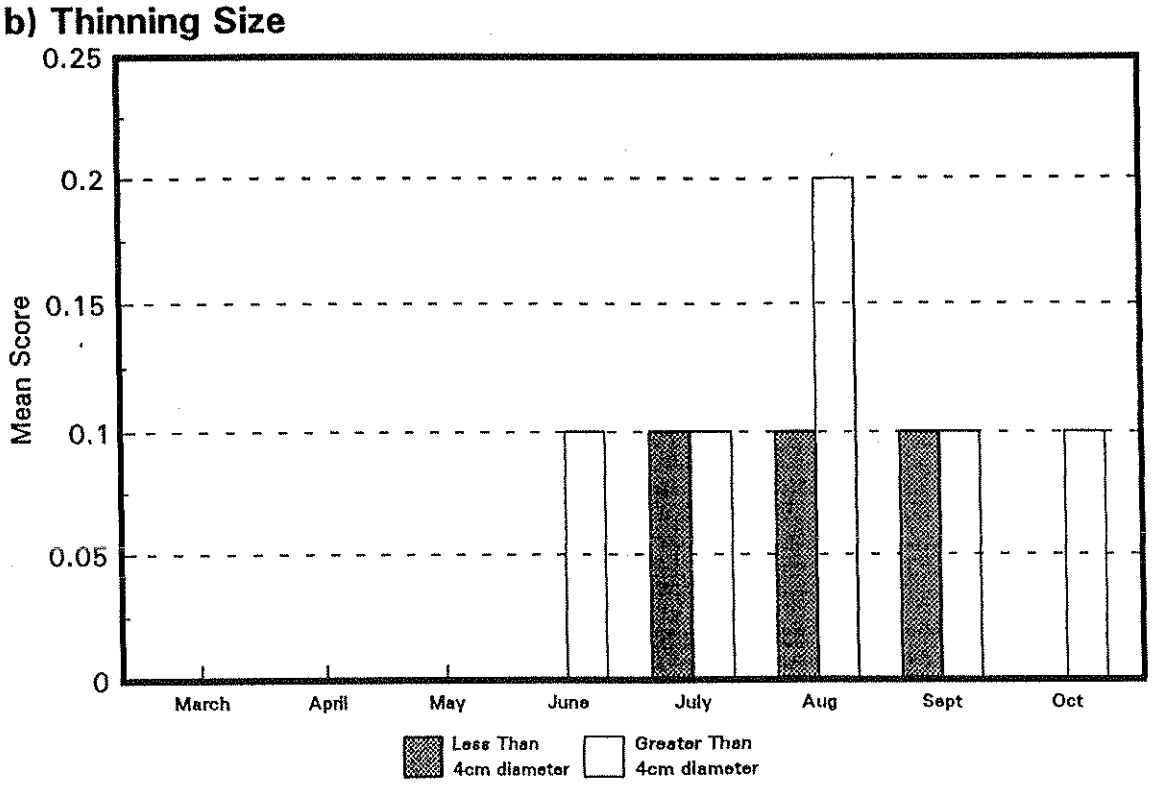

16
14
12
10
8
6
% Dry Matter
March
April
May
June
July
Aug
Sept
Oct
With Anchors
Without Anchors

Fig 4: Longitudinal cracking (0 = none, 5 = severe).





c) Anchors

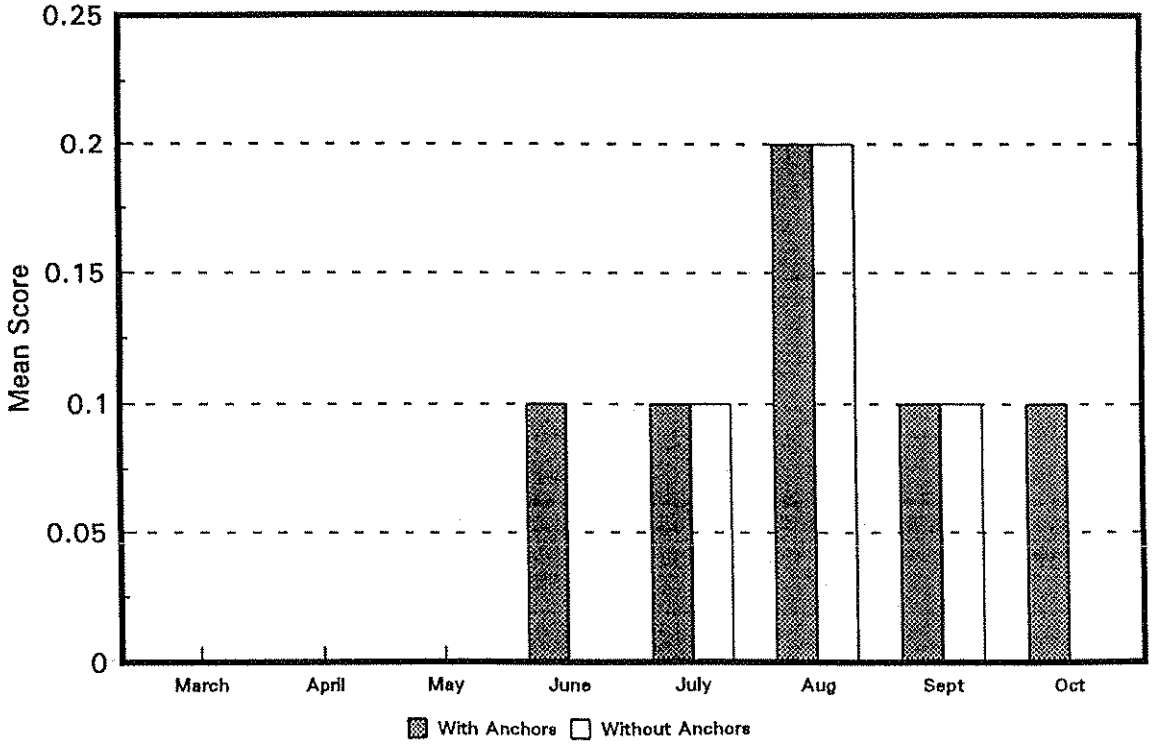
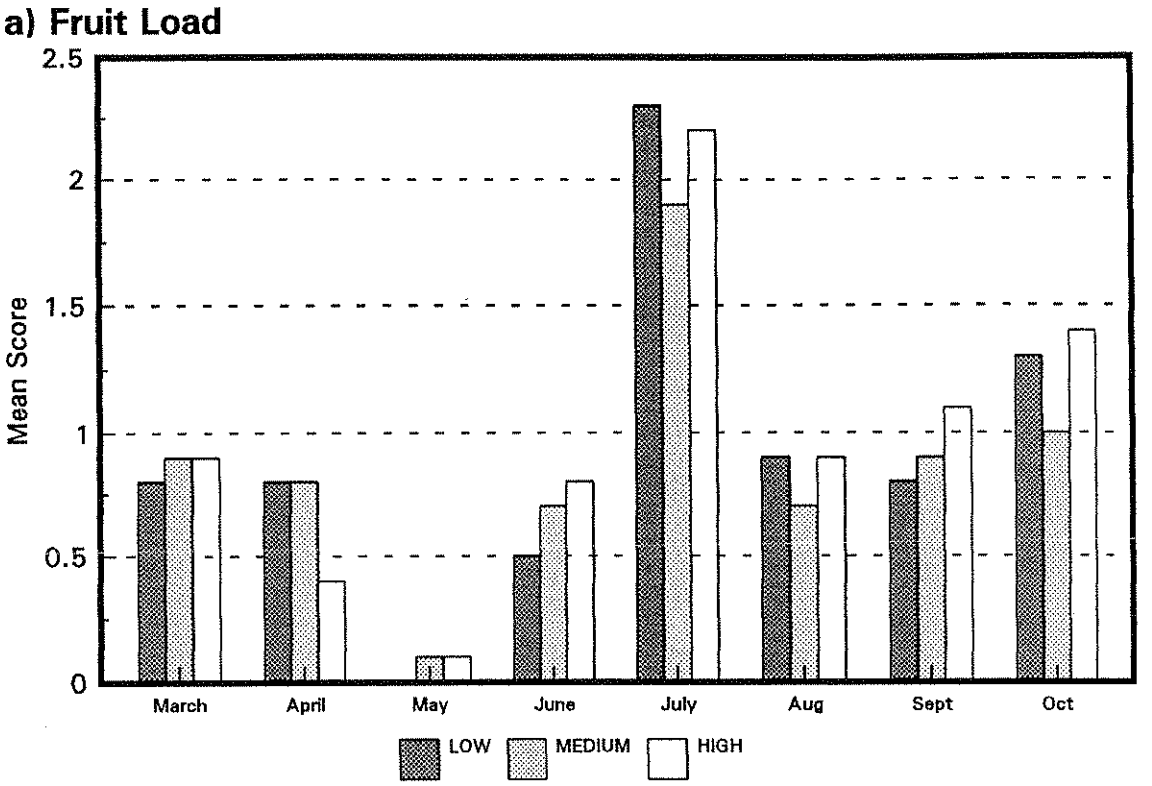
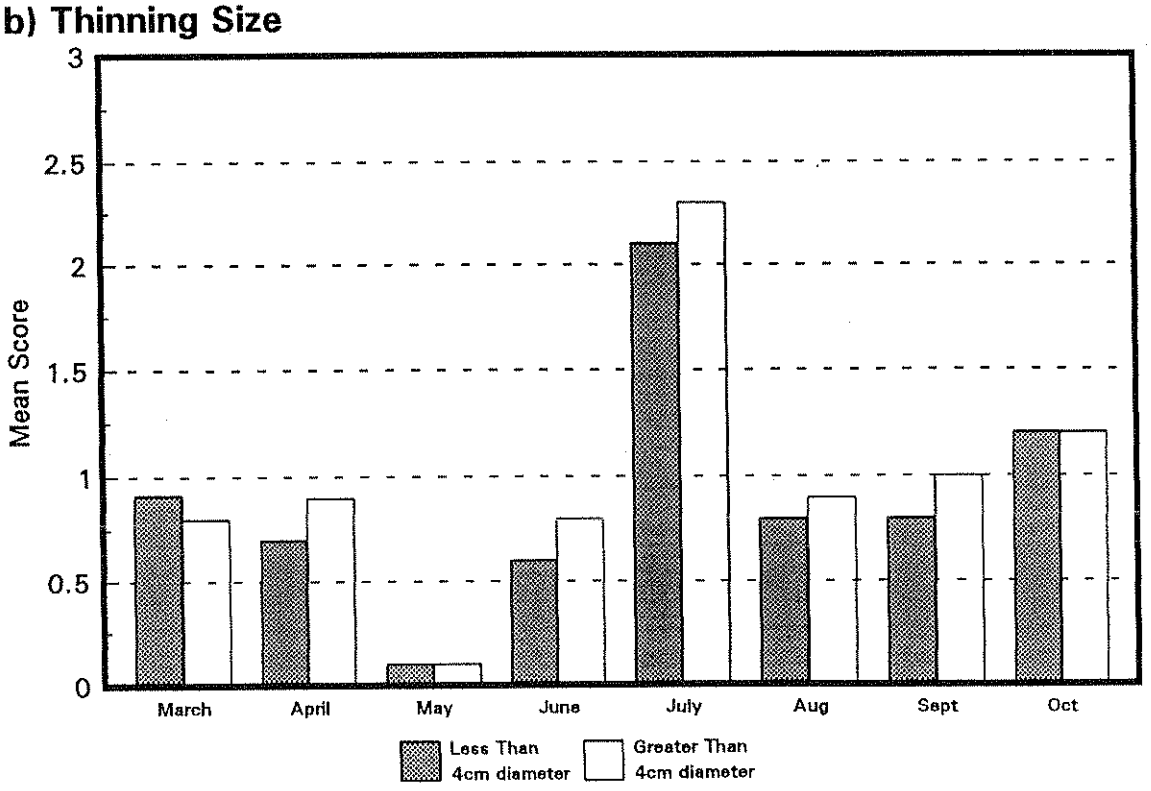

0.25
0.2
0.15
0.1
0.05
0
Mean Score
March
April
May
June
July
Aug
Sept
Oct
With Anchors
Without Anchors

Fig 5: Calyx lifting (0 = none, 5 = severe).





c) Anchors

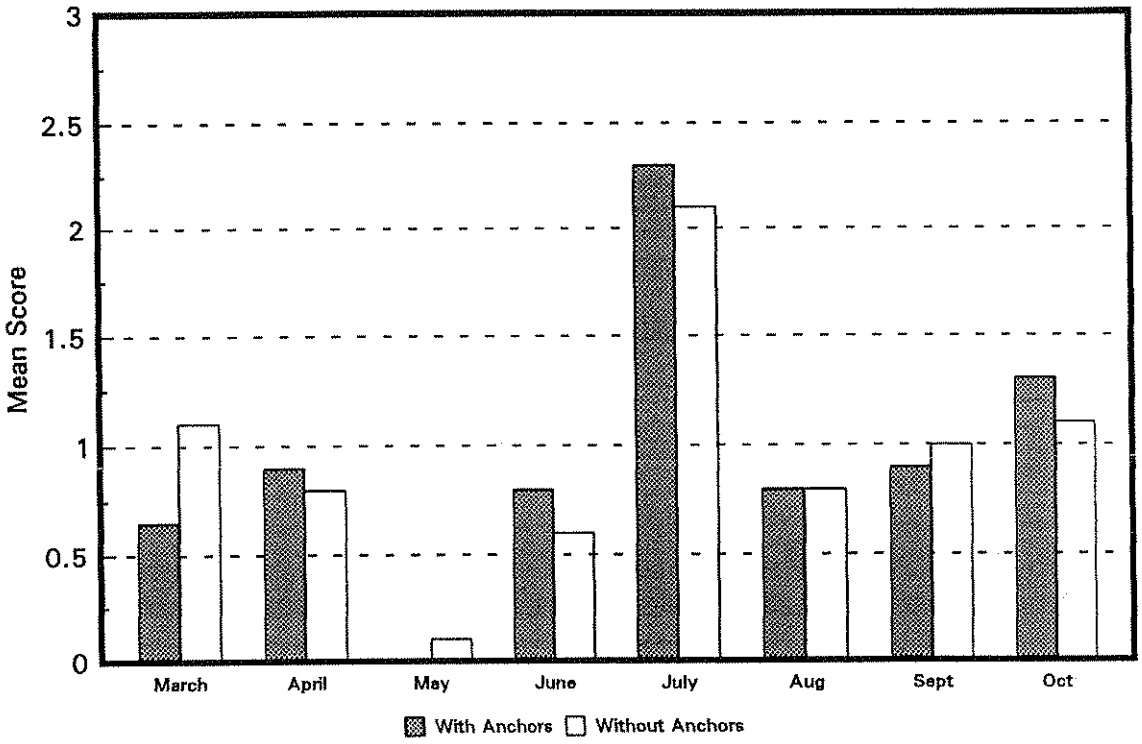
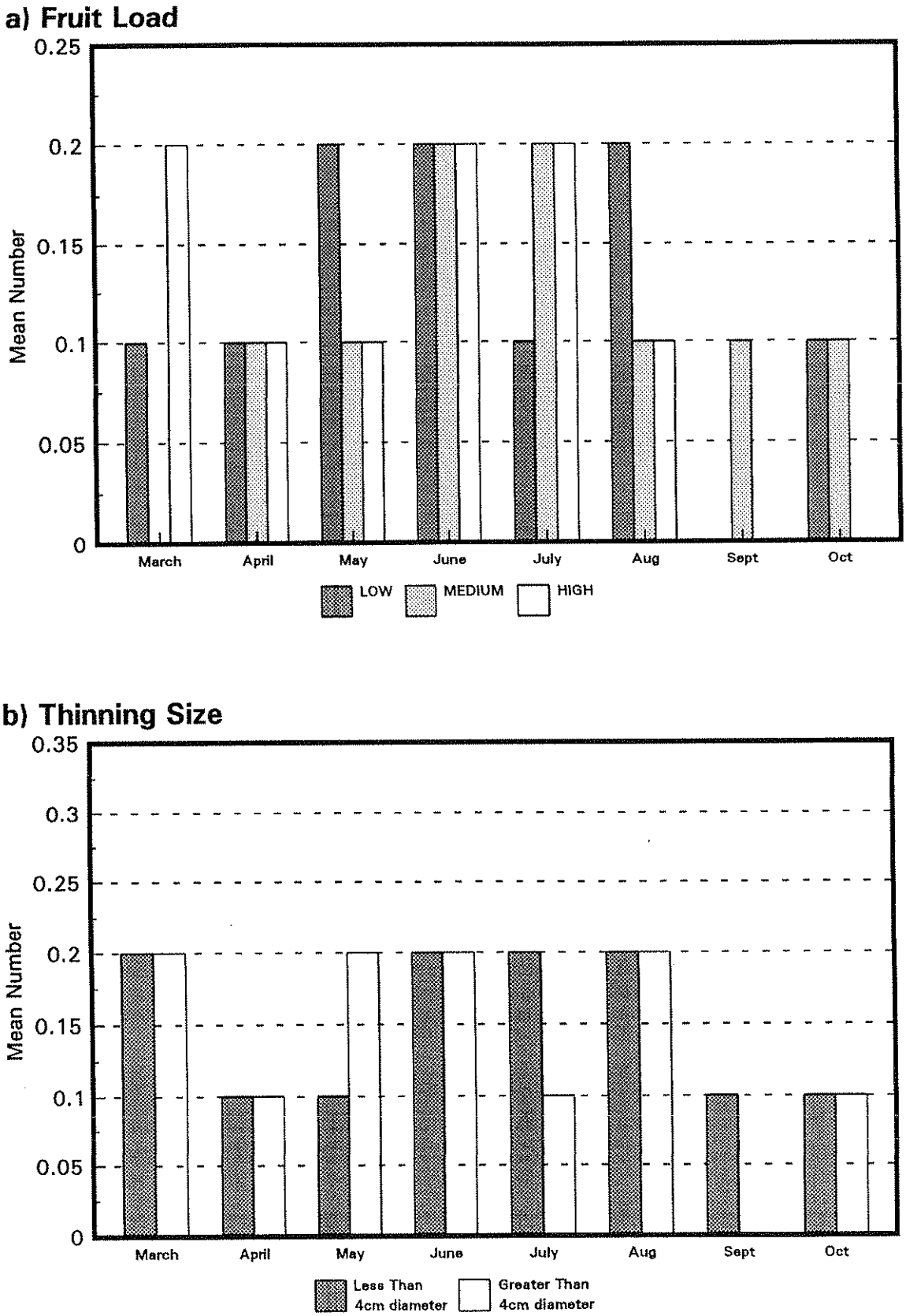
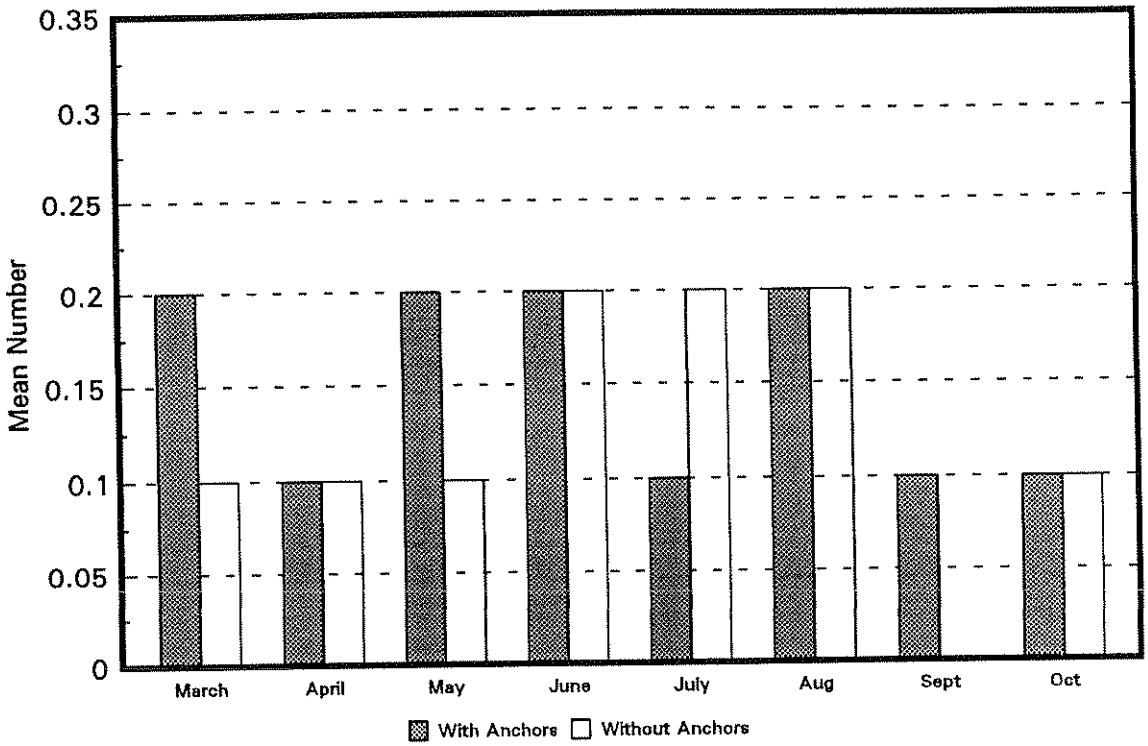

3
2.5
2
1.5
1
0.5
0
Mean Score
March
April
May
June
July
Aug
Sept
Oct
With Anchors
Without Anchors

Fig 6: Number of internal and external ears.

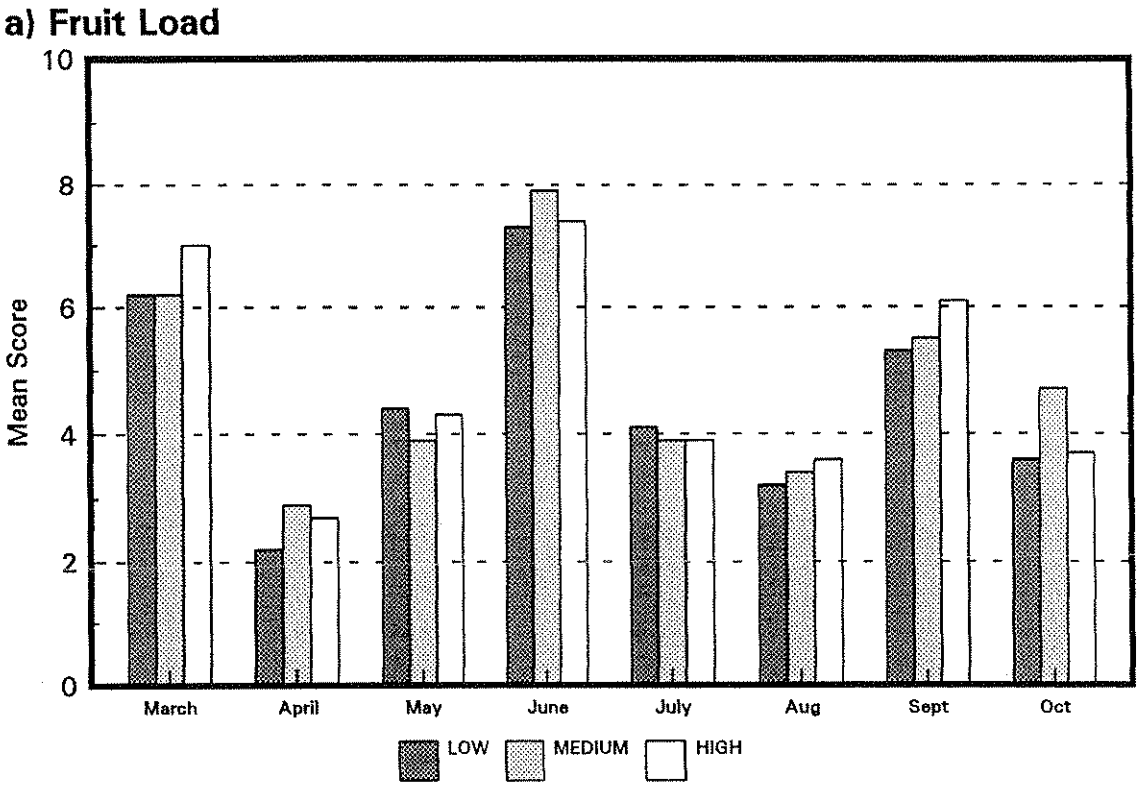


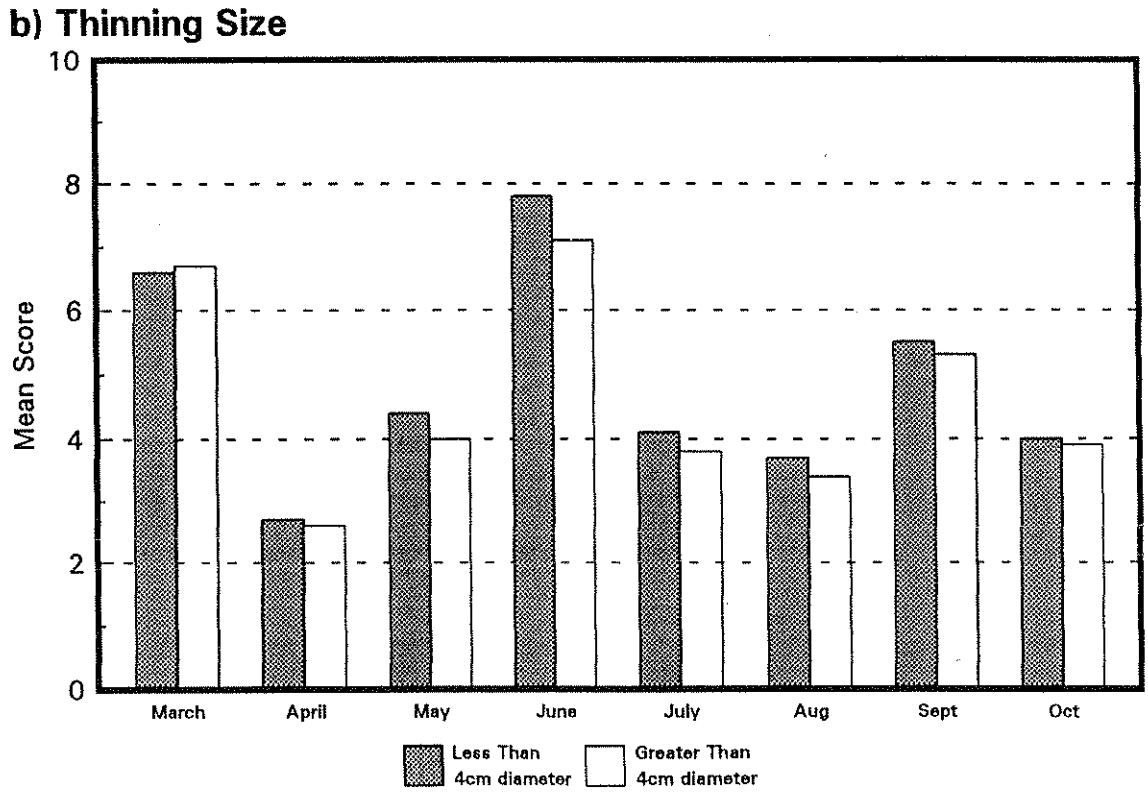
c) Anchors


0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Mean Number
March
April
May
June
July
Aug
Sept
Oct
With Anchors
Without Anchors

APPENDIX II: SHELF LIFE

Fig 7: Fruit shrivelling after 6 days (0 = none, 9 = severe).





c) Anchors

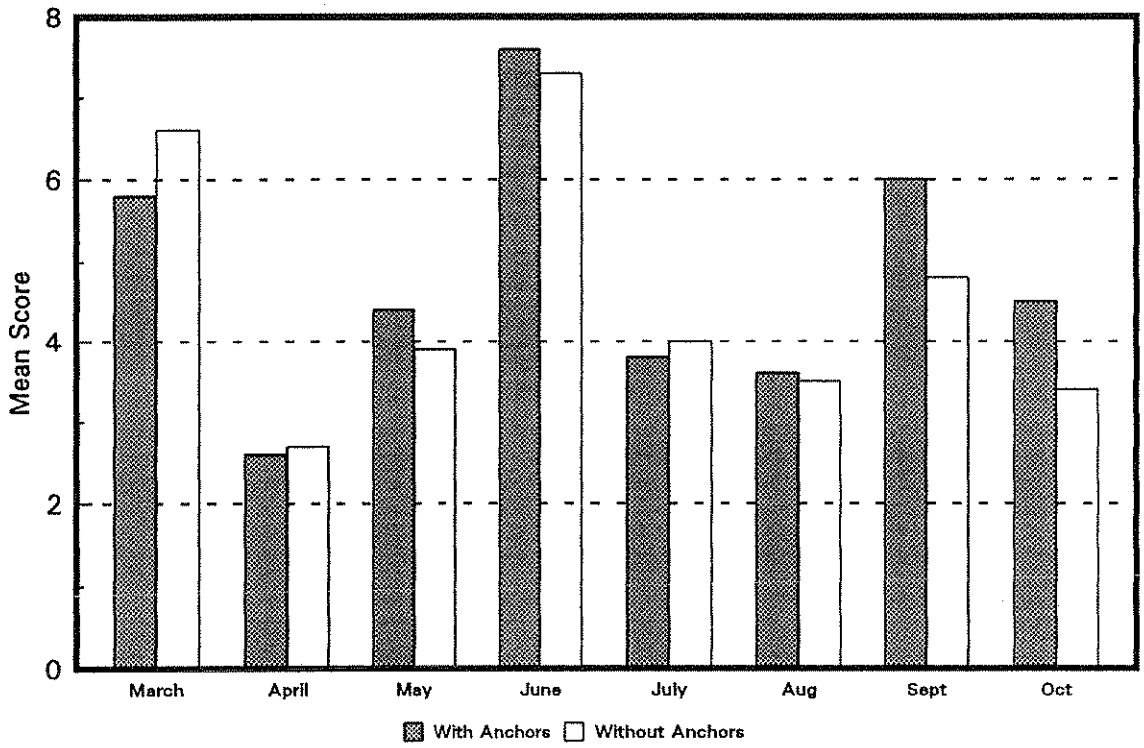
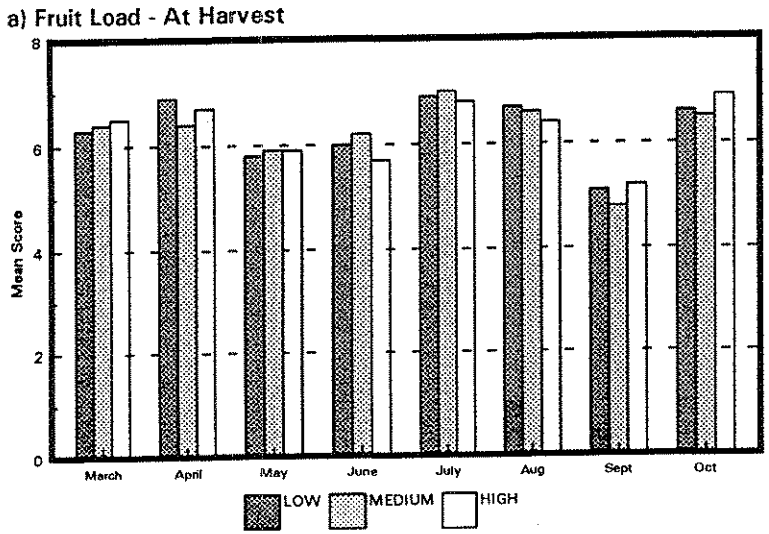
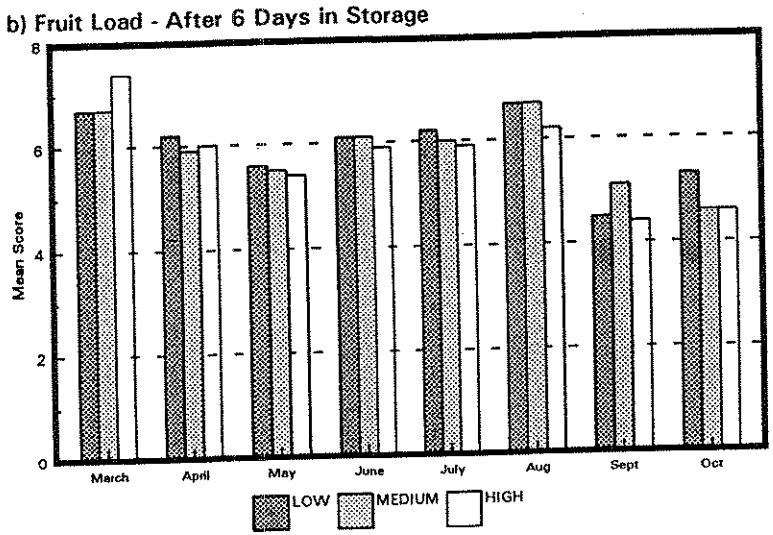
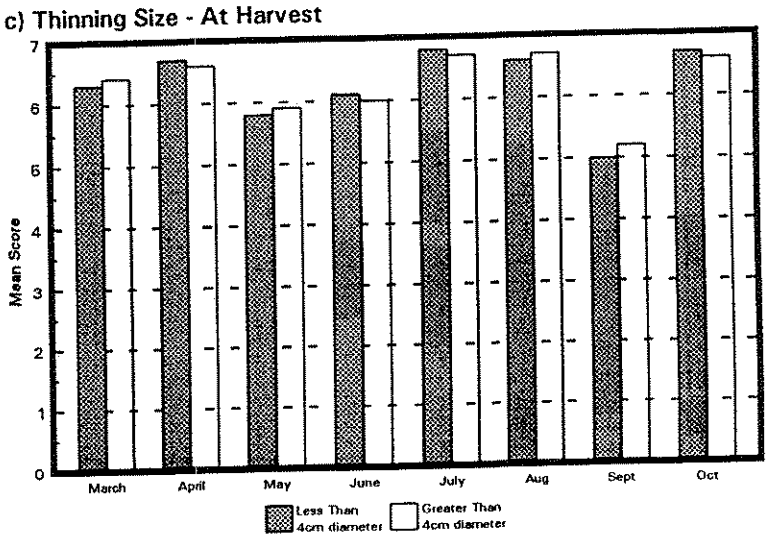
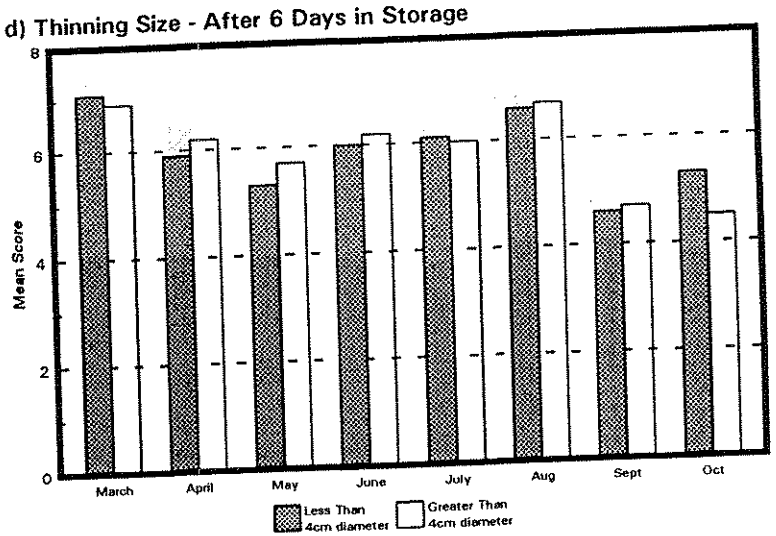

8
6
4
2
0
Mean Score
March
April
May
June
July
Aug
Sept
Oct
With Anchors
Without Anchors

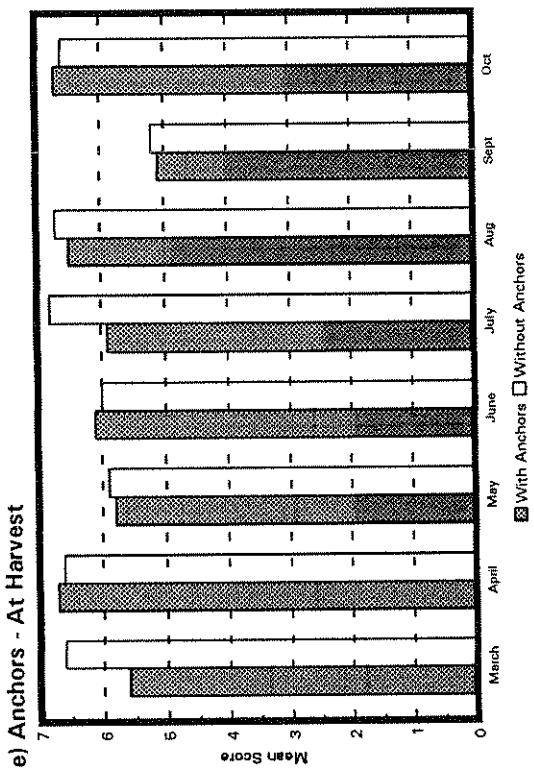
Fig 8: Fruit shine (0 = dull, 9 = very good shine).










e) Anchors - At Harvest
Mean Score
0
1
2
3
4
5
6
7
March
April
May
June
July
Aug
Sept
Oct
With Anchors
Without Anchors

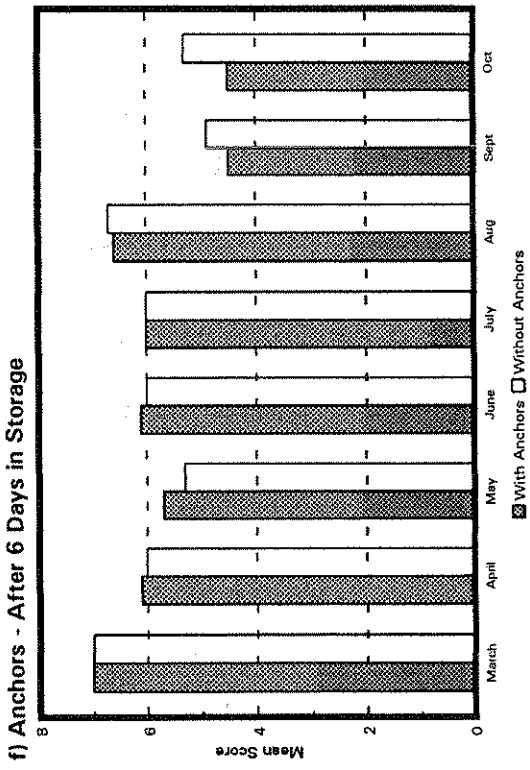
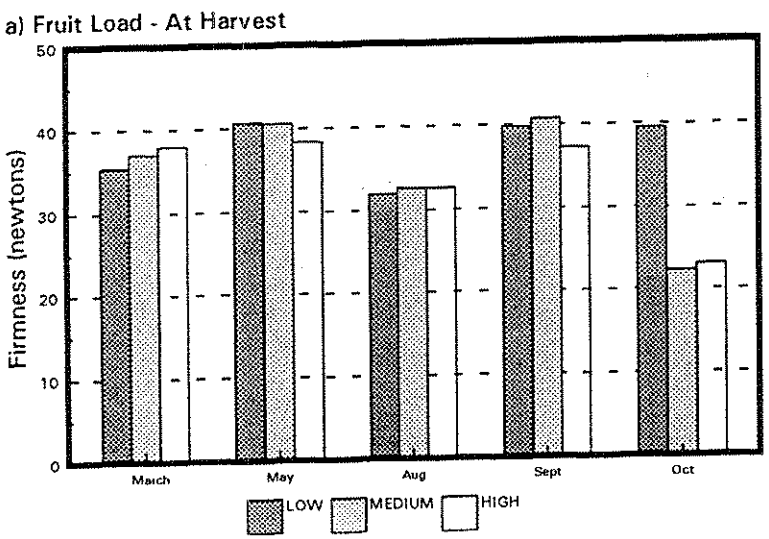
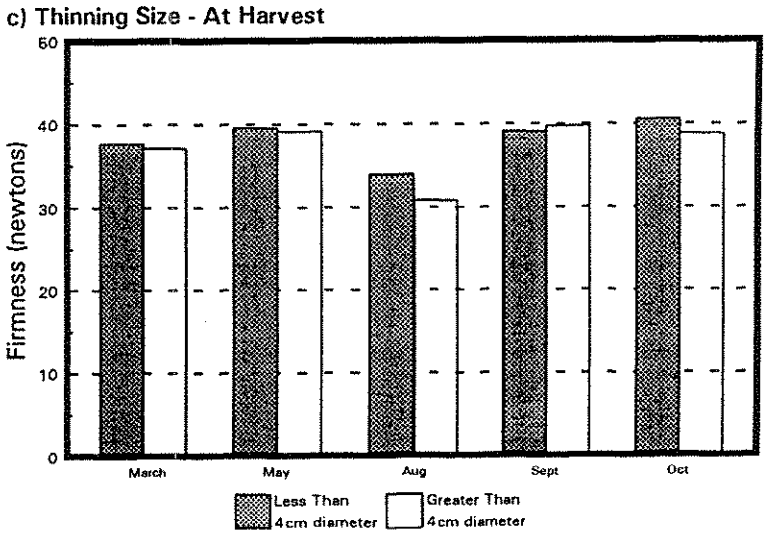
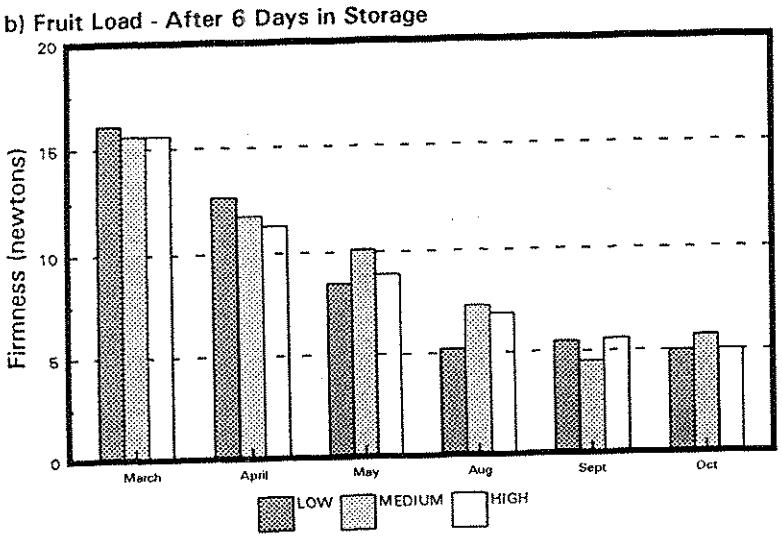

f) Anchors - After 6 Days in Storage
Mean Score
0
2
4
6
8
March
April
May
June
July
Aug
Sept
Oct
With Anchors
Without Anchors

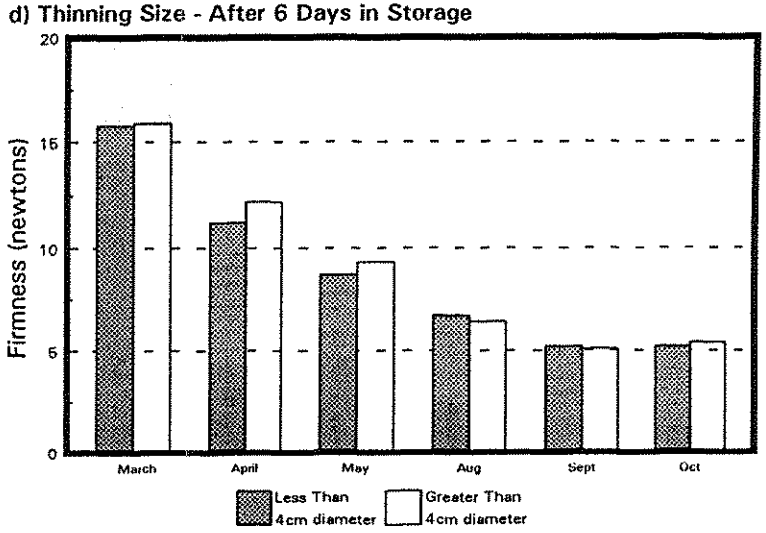
Fig 9: Fruit firmness.

NB: No data on fruit firmness at harvest is available for April.



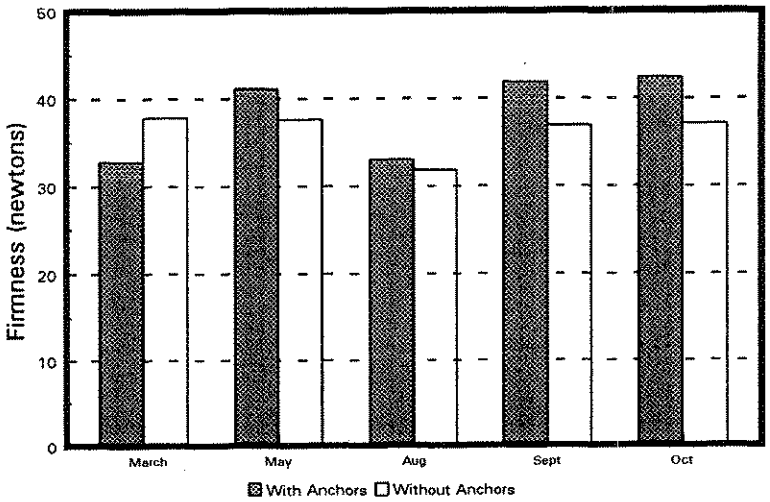






NB: No data on fruit firmness at harvest is available for April.

e) Anchors - At Harvest



f) Anchors - After 6 Days in Storage

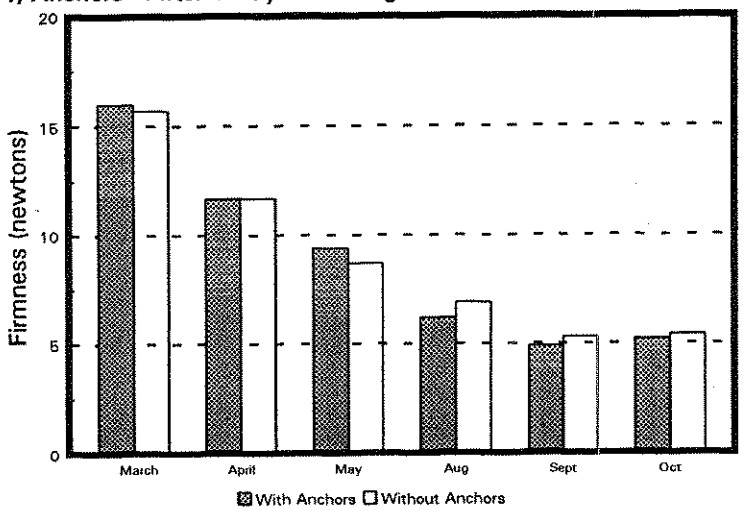
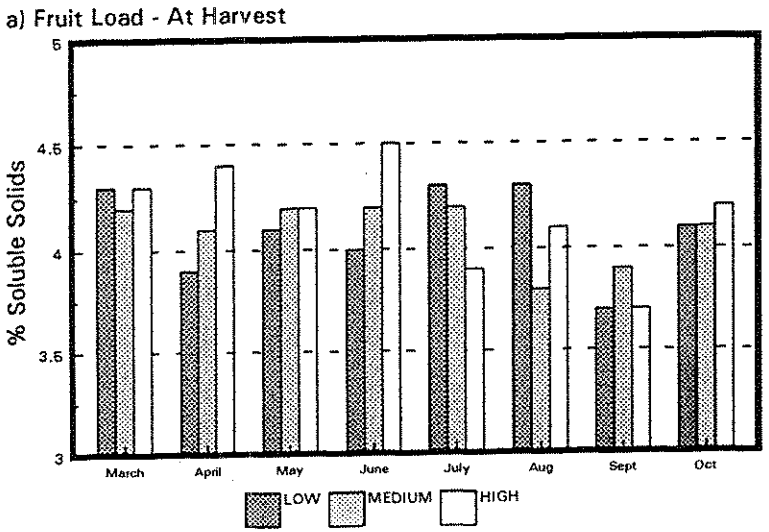
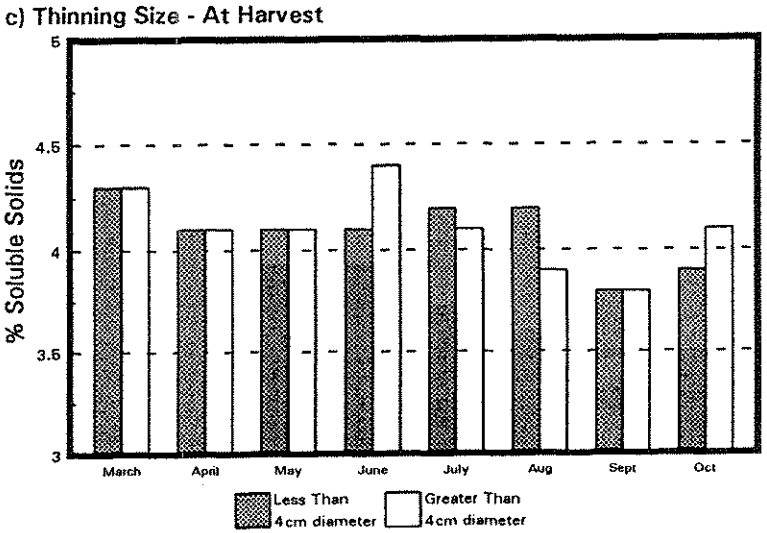
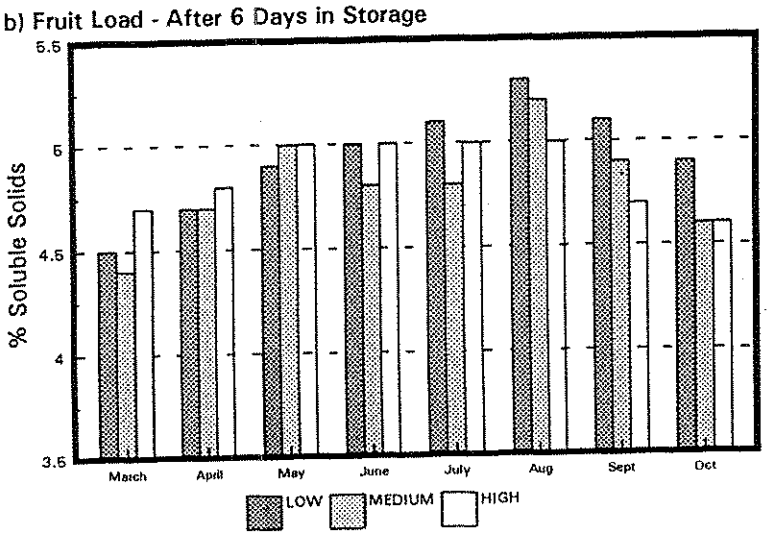
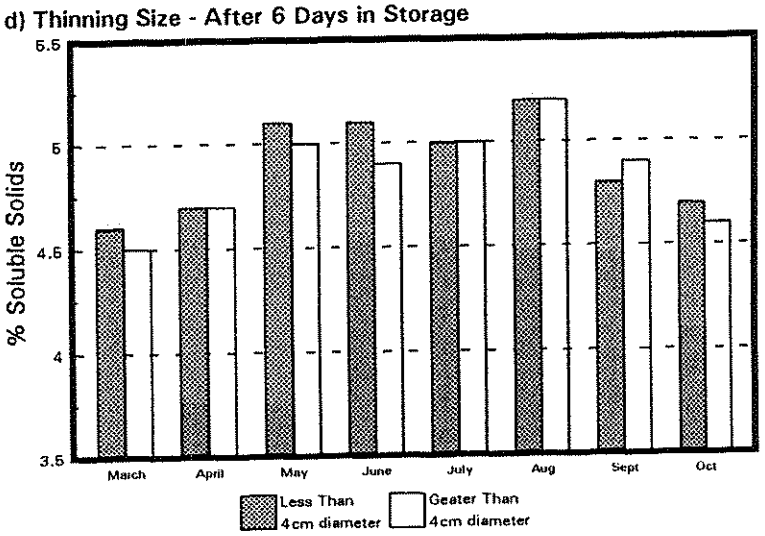


Fig 10: Fruit sugar content.

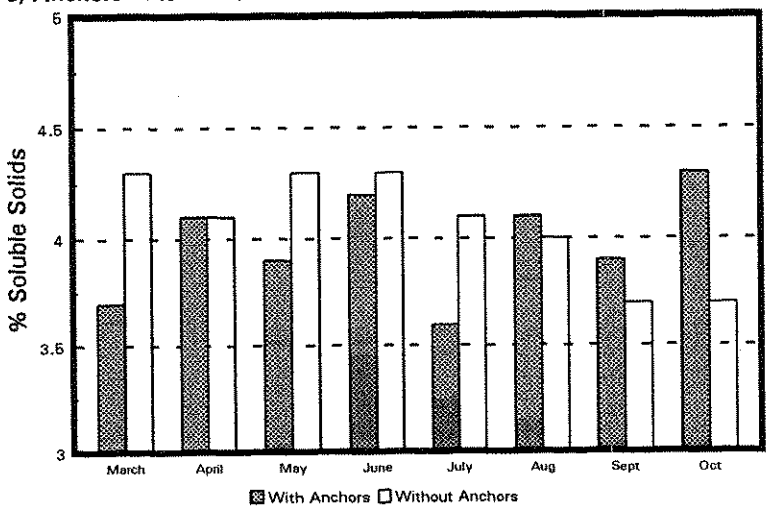








e) Anchors - At Harvest



f) Anchors - After 6 Days in Storage