

Project title: Annual monitoring of the maturity and quality of UK apples and pears

Project number: TF 114 [Previously APRC SP 114]

Report: Annual report 1997

Project leader: Martin Luton, ADAS & Tim Biddlecombe, FAST

Key words: apple, pear, Cox, Conference, fruit quality

This project report was originally issued by the Apple & Pear Research Council, under project number SP 114.

Whilst reports issued under the auspices of the HDC are prepared from the best available information, neither the authors nor the HDC can accept any responsibility for inaccuracy or liability for loss, damage or injury from the application of any concept or procedure discussed.

The contents of this publication are strictly private to HDC members. No part of this publication may be copied or reproduced in any form or by any means without prior written permission of the Horticultural Development Council.

© 2003 Horticultural Development Council

UK APPLE AND PEAR MATURITY PROGRAMME 1997/98

INTRODUCTION

English Apples and Pears Ltd formed the Quality Fruit Group in Spring 1994 to provide the UK Fruit Industry with detailed technical information on growing, harvesting and storage methods designed to ensure optimum texture and flavour in Cox apples and Conference pears. The main work of the group was to set up a UK fruit maturity programme to give growers clear guidelines on optimum harvest dates for long term storage each season and to provide data to improve our knowledge on the effects fruit maturity has on fruit quality after 4 and 7 months storage in ultra low oxygen.

The project involved taking samples of Cox apples from 32 orchards and Conference pears from 12 orchards twice a week and measuring fruit size, colour, firmness, sugar content, acidity and starch pattern. The results from three years work clearly showed there was a significant variation in fruit maturity between the sites and that there was as much variation within a geographical area as between. This variation was reflected in a similar range of optimum harvest dates for long term storage as indicated by the subsequent storage tests.

In a separate study funded by the APMC the harvest and storage data were used to produce a mathematical model for growers to predict fruit quality after 4 and 7 months storage in 1.2% oxygen at harvest. Using this model and by carrying out maturity assessments in individual orchards, growers could calculate the optimum harvest date for each orchard depending on the proposed storage period.

Unfortunately the severe frost in April and May 1997 meant that the UK crop of both Cox and Conference was very much reduced and thus the industry had very little resources to fund the programme. However, it was recognised that the work was very important and thus the APMC agreed to fund for one year only a very much reduced programme.

This report describes the results from that work.

Materials

The previous three years work had highlighted the significant range in maturity attributes between samples of fruit from the 32 different Cox orchards. To ensure this range was represented, even using a reduced number of sites, the 32 sites were divided into early (first 10) average (next 12) and late (last 10) based on the calendar date they either reached a 70% starch pattern or the fruit firmness fell to 8.6kg in each of the three years.

As expected orchards moved between categories depending on season, however the three constantly early sites, 4 average and three late sites were selected which were carrying at least three quarters of a full crop. In a separate study staff from FAST carried out measurements in 5 orchards in the West Midlands and made the data available to the group.

In a similar way the 12 original Conference pear orchards were divided into early (first 6) and late (last 6) depending on the date fruit reached 2/3 maximum starch pattern or the maturity index reached 1. The three consistently early sites and two later sites were chosen from those orchards that had at least three quarters of a crop.

At each site, 20 trees were labelled along a single row adjacent to the rows used in the previous three years. This was done to eliminate any influence on cropping and fruit quality of the previous three years sampling. Trees were selected to have at least 100 fruit. Where this was not possible the number of trees labelled was doubled to 40 to provide sufficient fruit for the study and 4 x 30lbs of fruit for storage samples.

The trees were sampled on the 20/8, 23/8, 27/8, 3/9, 10/9, 17/9 and 24/9. The start date was anticipated as being three weeks before the optimum harvest window and the final sample a week after.

On each sampling occasion, two fruits were taken at random from within the cropping canopy making a total of 40 fruits per sample. In the case of trees carrying less than 100 fruits one apple was taken from each of 40 trees making a similar sample size. Fruits were taken in such a way as to represent all positional aspects of the tree.

On four occasions at 7 days intervals starting on 3 September, a further 30lbs of fruit was harvested from 5 (10) pre-labelled trees in the row by picking 6lb (3lb) of fruit from a complete segment of the tree. Once harvested, these trees were discounted from the study.

Methods

i. Maturity

Size

On arrival at Brogdale (within 4 hours of harvest) the 40 fruits in each sample were examined visually and the five largest and five smallest fruits were discarded. The remaining 30 apples and pears were weighed and the average fruit diameter calculated by measuring the total length of the 30 fruits arranged in a line, and dividing the resulting measurement in mm by 30. After being weighed and measured 10 pear fruit were taken at random and discarded to leave a total sample size of 20 fruits.

Acidity

Ten apples were taken at random from the 30 fruits and used to measure acidity. Opposite eights were cut and the stalk and pips removed. The fruit was homogenised in a blender and 10mls of the juice removed and titrated against N Na(OH)₂ to an end point of pH 7. The results were expressed as mg of malic acid per 100 gram of fruit.

The remaining 20 apples and pears were arranged on a fibre cell liner and the first 10 fruits numbered 1-10 using a fibre pen. These fruits were assessed individually for colour, firmness, soluble solids and starch patterns, and the record kept separately to allow an index to be calculated for each apple.

Background Colour

Overall background colour was assessed visually for each of the ten Cox fruits using the ENFRU colour card which divides background colour in green (1), light green (2), light yellow (3) and yellow (4).

Fruit Firmness

A thin slice of peel was removed from opposite sides of the 10 numbered fruits and the firmness measured using an Effigi penetrometer mounted in a drill stand and fitted with an 11mm plunger for apples and an 8mm probe for pears. The results were expressed as kg force.

Soluble Solids

A sample of juice was taken from each numbered apple or pear using a plastic probe, and placed in a hand held refractometer with a scale of 0-20%. The % soluble solids present in each fruit was recorded. At the start and end of each days reading the instrument was calibrated using a set of standard sugar solution (8, 10, 12 and 14%w/v). Using this calibration curve the individual fruit readings were adjusted.

Starch

Each of the 20 fruits were then cut transversely through the equator and the cut surface dipped in a solution of 1% iodine and 4% potassium iodide. After 10 minutes the percentage area stained black was measured using a transparent sheet printed with a series of gauges ranging in diameter from 45-70mm, each gauge had printed on it a series of concentric rings representing 90%-50% starch pattern.

ii. C.A. Storage

On 3, 10, 17 and 24 September a 30lb box of fruit was harvested from 5 pre-labelled Cox trees as already described. Using this fruit four x 20 fruit netted storage samples were made up. The samples were transported and placed in a commercial controlled atmosphere store at $<1\%CO_2$ $1.2\%O_2$ $3.5^\circ C$. On each occasion the fruit was initially placed in a coldstore for 7 days to ensure it was thoroughly cooled. The four nets from each site were then placed in two empty bulk bins which had previously been left under the hatch of a 100 ton commercial store. Two nets from each site and each pick were placed in each bin to facilitate removal of samples in January and February.

On 20 January, two nets from each orchard and each harvest date were removed to assess fruit quality. One twenty fruit sample was used to carry out initial measurement of background colour, soluble solids and fruit firmness as previously described. The fruit was then assessed externally for any sign of fungal infection before being cut and the internal condition of the fruit recorded.

The second netted samples were placed at 18°C for 10 days before being assessed for internal and external condition. On 31 January John Chapman of FAST Ltd carried out a taste test on each sample and scored the fruit for texture, aroma and flavour.

On 13 February the remaining two nets from each orchard and harvest date were removed from store and assessed as before.

RESULTS

1. Harvest

The average fruit weight, diameter, background colour, soluble solids, acidity, firmness and starch pattern was calculated for each orchard on each sample date.

For each of the 10 individual fruits in the sample a maturity index was calculated as follows. The % starch was converted into a 1-10 scale using a conversion table (Table 1).

TABLE 1. Relationship between % starch pattern and 1-10 scale.

% STARCH (Black)	1-10 SCALE	% RANGE
100	1	100
80	2	77.6 - 99.9
75	3	70.1 - 77.5
65	4	57.6 - 70.0
50	5	40.1 - 57.5
30	6	27.6 - 40.0
25	7	17.6 - 27.5
10	8	7.6 - 17.5
5	9	2.6 - 7.5
0	10	0 - 2.5

Using the following formula the index for each of the 10 individual numbered apples and pears in the sample was calculated.

$$\text{Firmness (kg)} \times 9.81$$

$$\text{Soluble solids (\%)} \times \text{starch pattern (1-10)}$$

The mean maturity index for each orchard at each sampling date was found by taking the average of the 10 individual fruits.

Graphs were plotted of fruit firmness, starch pattern and maturity index with time using the data collected from mid August until late September at each site (Appendix 1). A linear regression was fitted to both the fruit firmness and starch pattern data. The date at which the average fruit firmness fell to 8.6kg and the starch pattern declined to 70% was calculated from these regressions. A curve was fitted to the maturity index data and the date the index reached 2.1 extrapolated (Table 2).

For each of the 5 pear orchards graphs of change in fruit firmness, starch pattern and maturity index with time were plotted (Appendix 2). From these graphs the date the starch pattern reached 2/3 maximum and 1/3 maximum was extrapolated together with the date the maturity index reached 0.7 and fruit firmness fell to 6kg (Table 3).

TABLE 2. Date at which average fruit at each Cox site reached 65mm diameter, a starch pattern of 70%, a firmness value of 8.6kg (11mm probe) and an index of 2.1 in 1997.

ORCHARD DETAILS			CALENDAR DATE			
Area	Orchard Ref. No	Rootstock	Average Diameter 65mm	70% Starch	Firmness 8.6kg	Index 2.1
Kent (K)	K1	MM106	23/8	3/9	12/9	5/9
	K3	MM106	3/9	2/9	31/8	4/9
	K7	M9	23/8	5/9	5/9	4/9
	K10	MM106	23/8	30/8	31/8	1/9
	K11	M9	27/8	28/8	17/8	31/8
	K12	M9	10/9	26/8	19/8	27/8
Essex (E)	E4	M9	17/9	3/9	7/9	3/9
Suffolk (SF)	SF2	M9	3/9	5/9	8/9	7/9
	SF5	M9	3/9	5/9	8/9	4/9
Norfolk (N)	N3	M9	27/8	4/9	7/9	5/9
West Midlands (WM)	WM3	MM106	3/9	19/9	12/9	21/9
	WM4	MM106	3/9	28/9	1/10	23/9
	WM5	M9	20/8	14/9	16/8	15/9
	WM6	M9	3/9	9/9	15/8	10/9
	WM7		3/9	10/9	24/9	19/9

TABLE 3. Date at which average fruit at each Conference site reached a diameter of 55mm, two thirds of maximum and one third of maximum starch pattern, a maturity index of 0.7 and a firmness of 6.0kg in 1997.

Area	Orchard Ref No	Average Diameter 55mm	Starch 2/3	Starch 1/3	Index 0.7	Firmness 6.0kg
Kent (KP)	KP1	3/9	9/9	21/9	19/9	15/9
	KP3	10/9	4/9	20/9	18/9	9/9
	KP4	10/9	6/9	22/9	19/9	18/9
	KP6	3/9	13/9	23/9	21/9	12/9
East Anglia (EAP)	EAP2	10/9	15/9	23/9	20/9	13/9

II. Storage

The average fruit firmness, soluble solids and background colour of ten fruits was calculated for each orchard at each pick after 20 weeks in Controlled Atmosphere storage. The number of fruit in each sample with fungal infection or internal storage disorders was noted. After 10 days at 18°C the fruit was tasted and scored for texture, taste and aromatic quality on a 0-10 scale with 5 being optimum. The number of apples in each sample showing fungal infection and internal storage disorders were noted (Appendix 3).

The average fruit firmness, soluble solids and background colour of ten fruits was calculated for each orchard at each pick after 23 weeks in controlled atmosphere storage and after 10 days shelf life at 18°C (Appendix 4).

DISCUSSION

1. Cox

As in the previous three seasons average fruit size increased by about 2.5mm a week during August. In early September the rate of increase fell until after the 10th of the month no increase in average fruit size was recorded. (Figure 1).

In general fruit size was 4mm larger than recorded at a similar time in the last three seasons. This was mainly due to the light crop (50 - 75%) carried by most trees in 1997 due to the spring frosts. Overall, fruit size reached 65mm on 31 August in 1997, this was two weeks earlier than in 1994 or 1996 and about a week earlier than in 1995. The Kent sites on average reached 65mm on 29 September, this was 2 days before the West Midland sites and a week before the East Anglian sites (Table 4).

TABLE 4. Date on which mean fruit size reached 65mm at the average site in 1994, 95, 96, 97 and for the average site in Kent, East Anglia and the West Midland areas.

CALENDAR DATE FRUIT SIZE REACHED 65MM				
Year	All sites	Kent Sites	East Anglian Sites	West Midland Sites
1994	13/9	10/9	16/9	29/9
1995	6/9	31/8	12/9	N/A
1996	15/9	11/9	20/9	3/9
1997	31/8	29/8	5/9	31/8

In 1997, average fruit background colour recorded in August was slightly paler than in previous seasons. During the first half of September it mellowed very slightly before changing significantly between the 17th and 24th (figure 2).

Initially soluble solids were about 1-1.5% lower than in previous seasons. However, during the last week of August they increased rapidly and then continued to rise by 0.12% a day to reach 12% by 8 September. This was similar to the situation in both

COUNTRY WIDE COX 1997 FRUIT SIZE(mm)

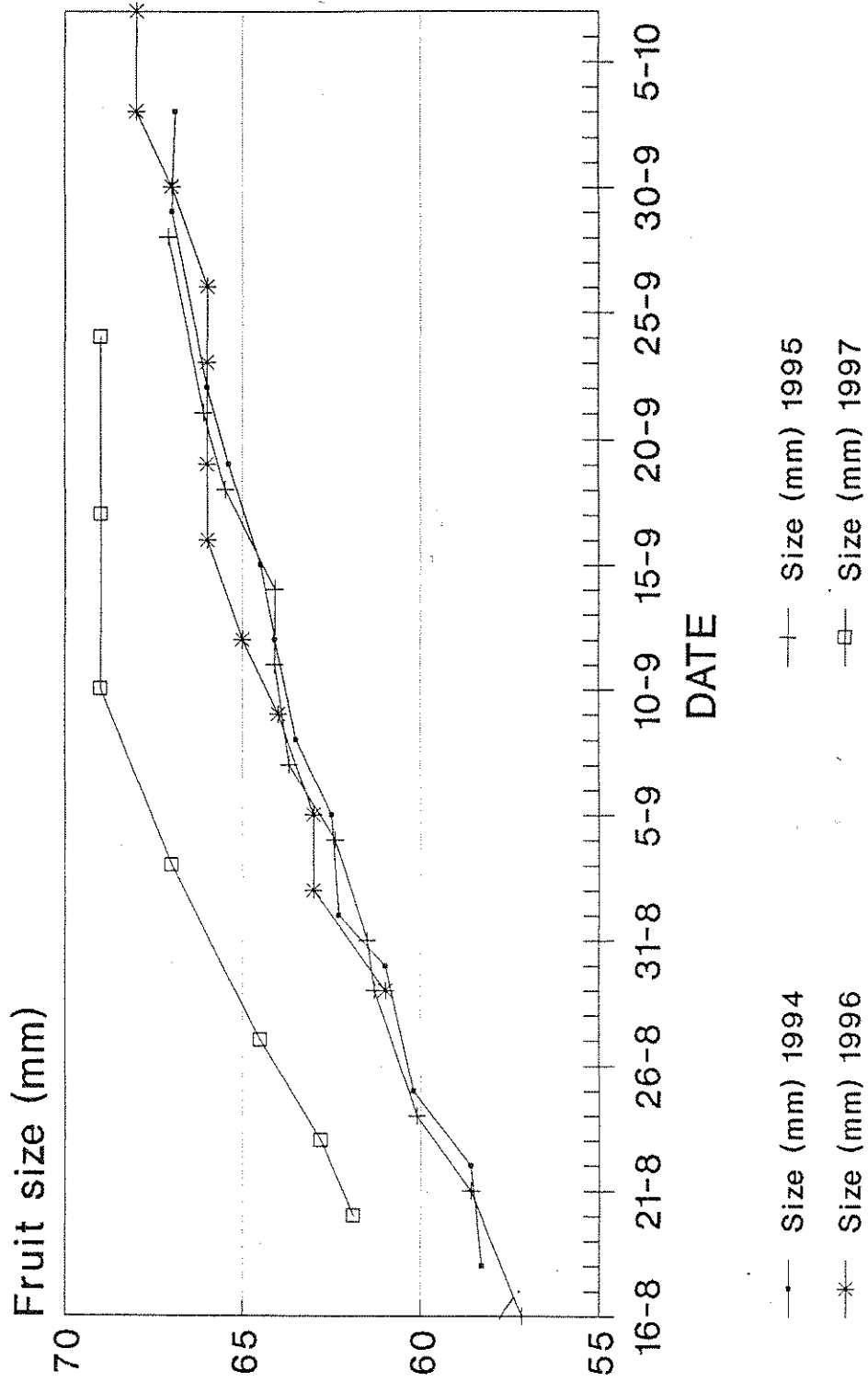


Figure 1

COUNTRY WIDE COX 1997

Background Colour

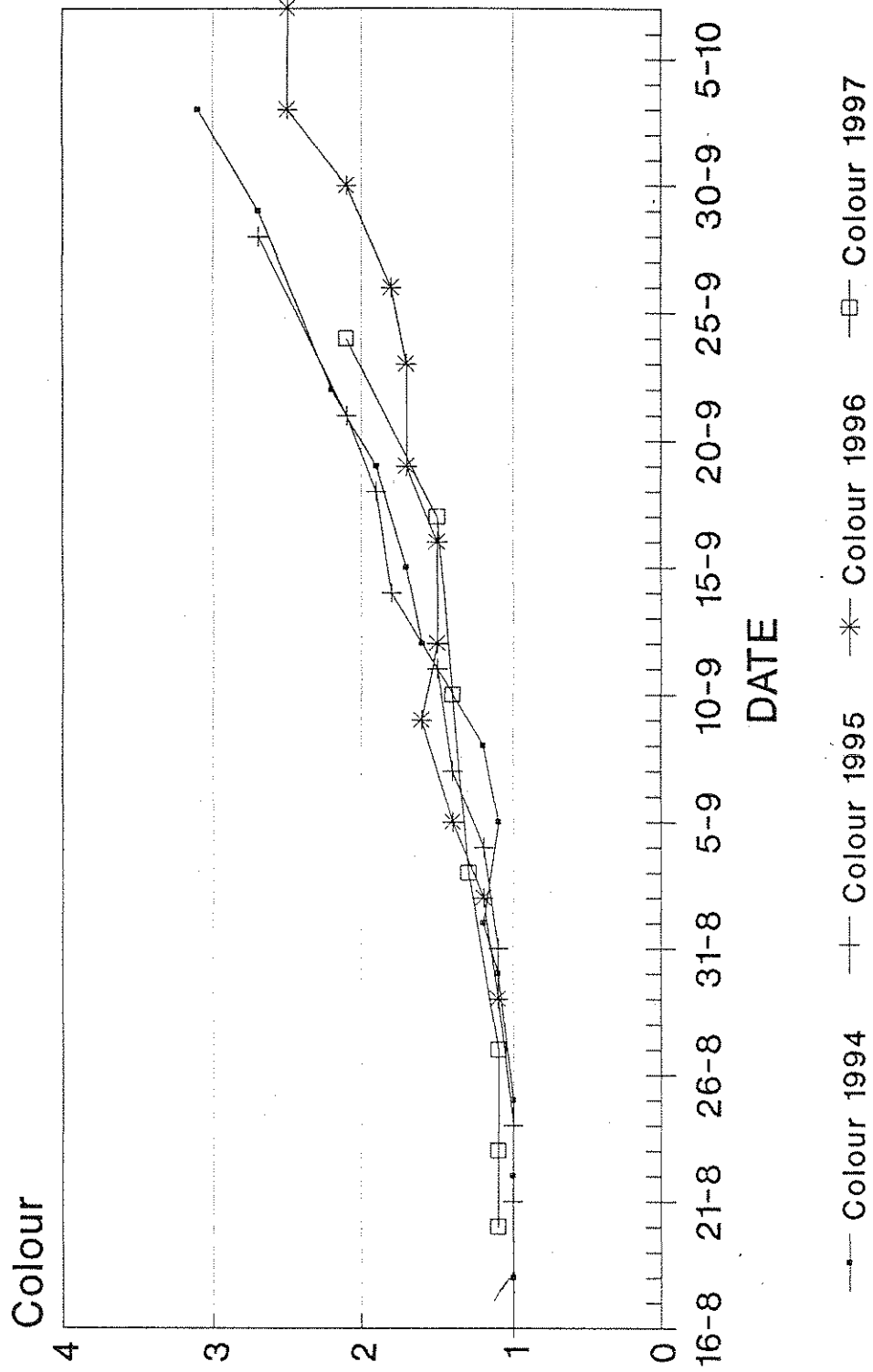


Figure 2

1994 and 1996 and about 1% lower than in the exceptionally high year of 1995 (Figure 3).

Fruit acidity decreased by about 0.5mg per week during the period of the study in 1997, this was similar to the previous three years. The initial concentration of about 11mg per 100grams was the same as that recorded in 1994 and 1995 but 1.0mg less than that recorded in 1996 (Figure 4).

Fruit firmness was initially about 2kg lower than that recorded at the same time in the previous three seasons. However, the rate of decline at 0.05kg a day was half that recorded in the previous three seasons of 0.10kg a day. Despite the slower fall the last picked fruit on 24 September was still 1-1.5kg below that recorded in the previous season (Figure 5).

Overall the average fruit firmness reached 8.6kg on 3 September, this was 2 weeks earlier than in 1994 and 1995 and three weeks earlier than the previous season. The Kent sites reached 8.6kg on 30 August, this was over a week before the East Anglian sites and over three weeks before the sites of the West Midlands. (Table 5).

TABLE 5: Date on which the mean fruit firmness reached 8.6kg at the average site in 1994, 95, 96 and 97 for the average site in Kent, East Anglia and the West Midlands area.

CALENDAR DATE FRUIT FIRMNESS REACHED 8.6Kg				
Year	All Sites	Kent Sites	East Anglia Sites	West Midland Sites
1994	17/9	16/9	17/9	>3/10
1995	17/9	16/9	17/9	>28/9
1996	25/9	22/9	25/9	>7/10
1997	3/9	30/8	8/9	>24/9

The decline in starch pattern at about 1.6% a day was slightly slower than the 2% recorded in the previous three seasons, however the decline started much earlier in 1997. (Figure 6) On average fruit starch pattern reached 70% on 7th September in 1997, this was two days earlier than in 1994 and about a week, and 10 days before 1995 and 1996 respectively. As with fruit firmness the Kent sites were in advance of the other areas, being over two weeks earlier than the West Midland average site (Table 6).

TABLE 6. Date on which mean fruit starch pattern fell to 70% at the average site in 1994, 95, 96, 97 and for the average site in Kent, East Anglia and the West Midlands area.

COUNTRY WIDE COX 1997 SOLUBLE SOLIDS(%)

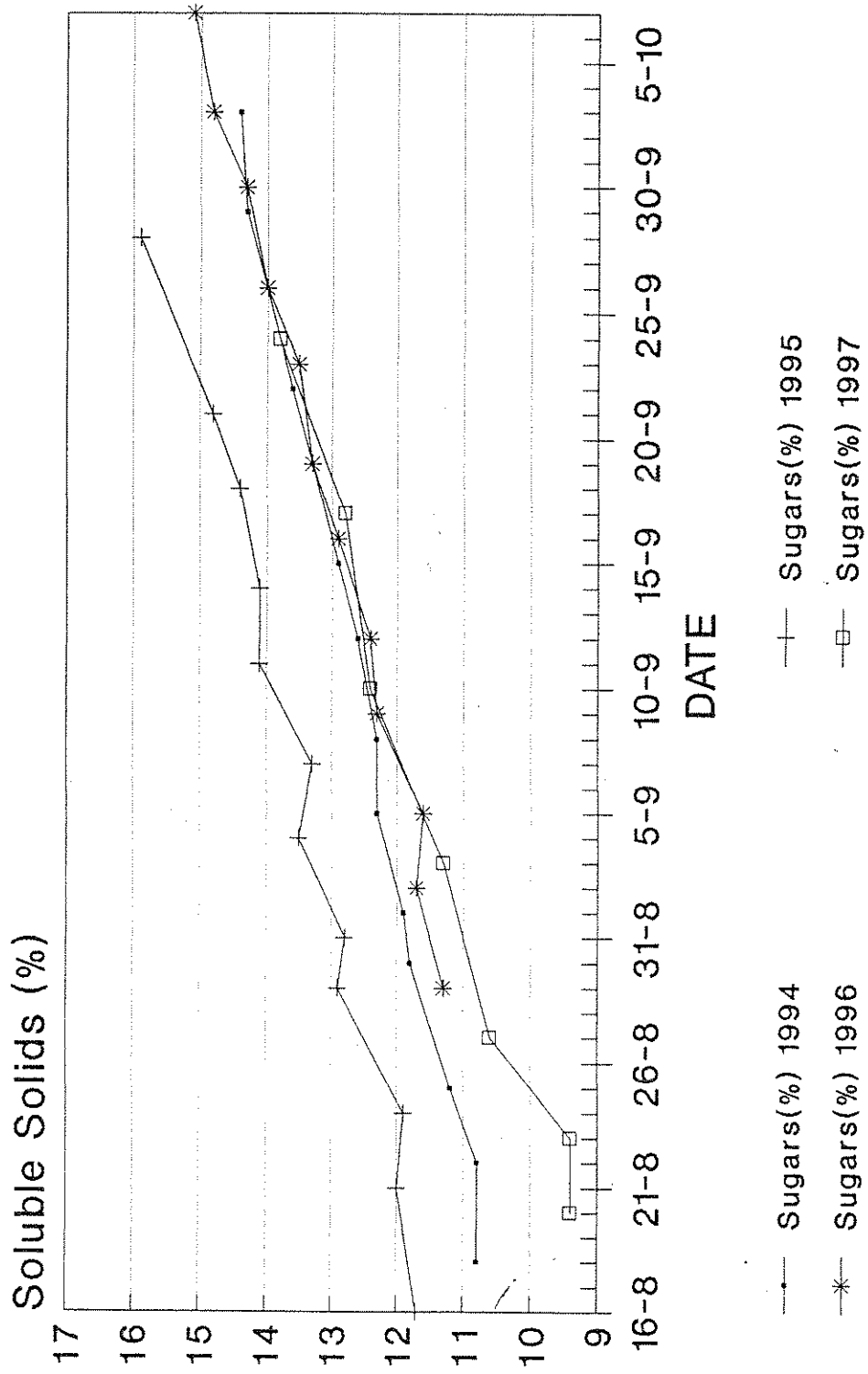


Figure 3

COUNTRY WIDE COX 1997 ACIDITY(mg)

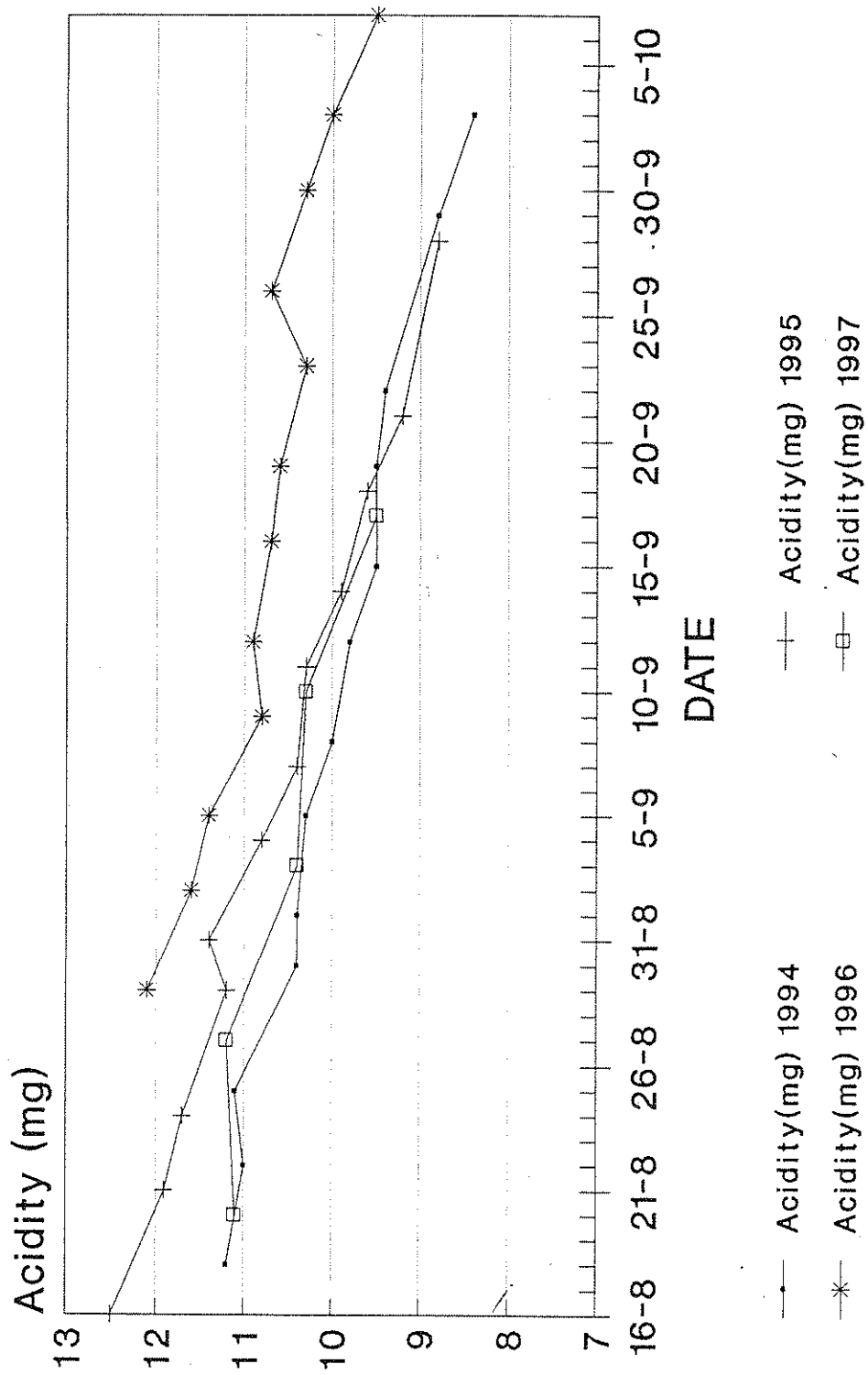


Figure 4

COUNTRY WIDE COX 1997

Firmness (kg)

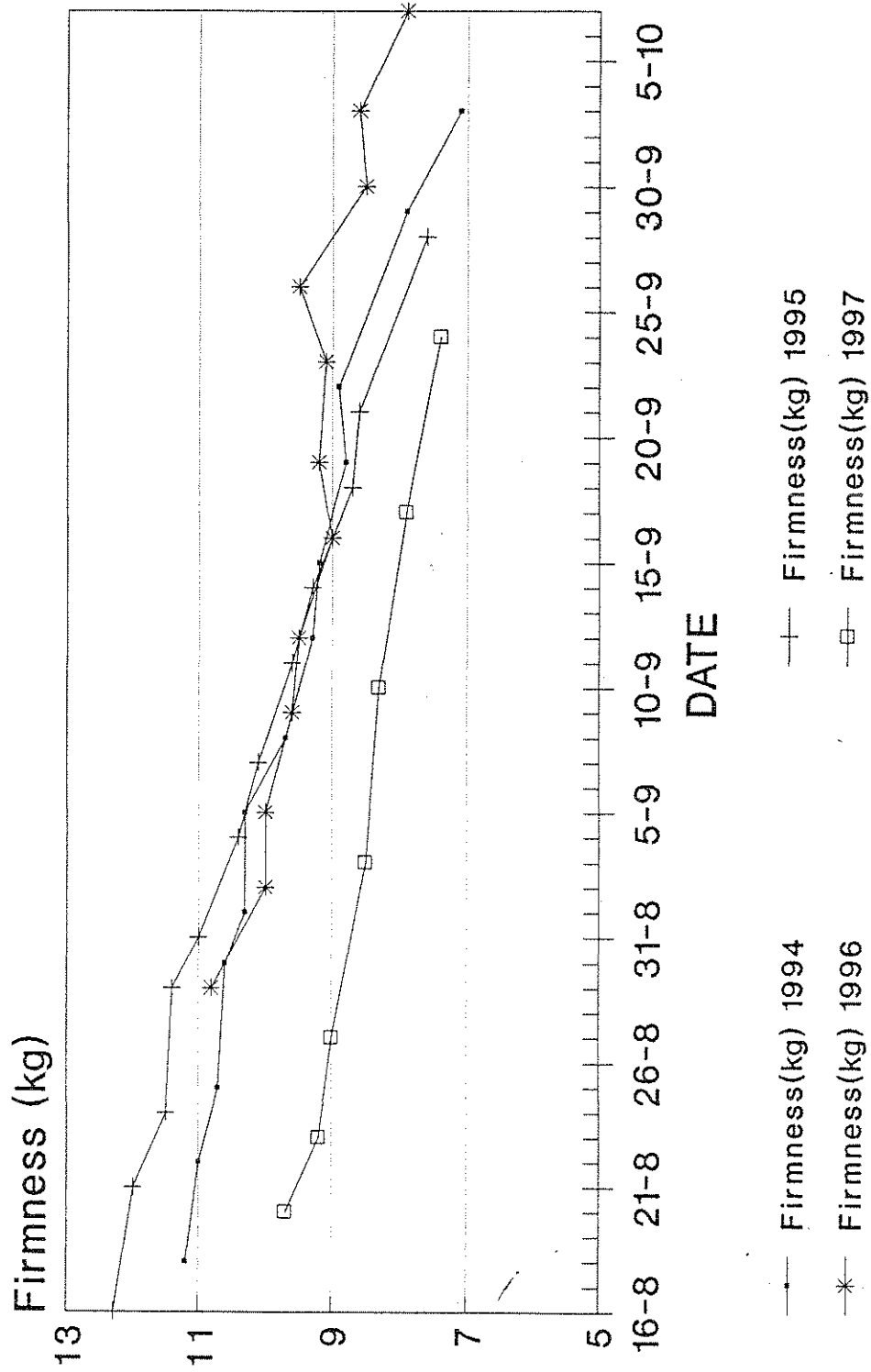


Figure 5

COUNTRY WIDE COX 1997

Starch (%)

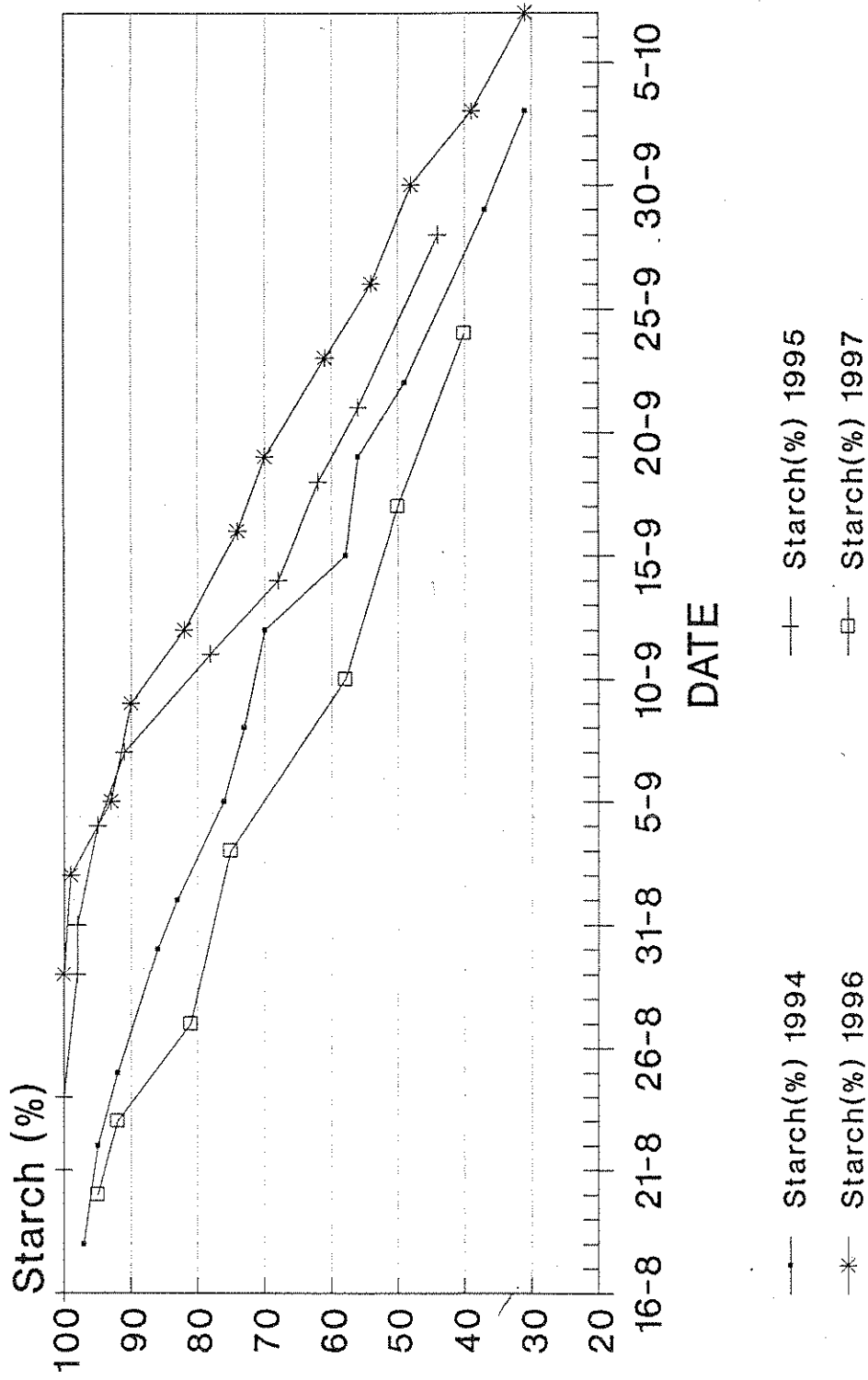


Figure 6

COUNTRY WIDE COX 1997 Index

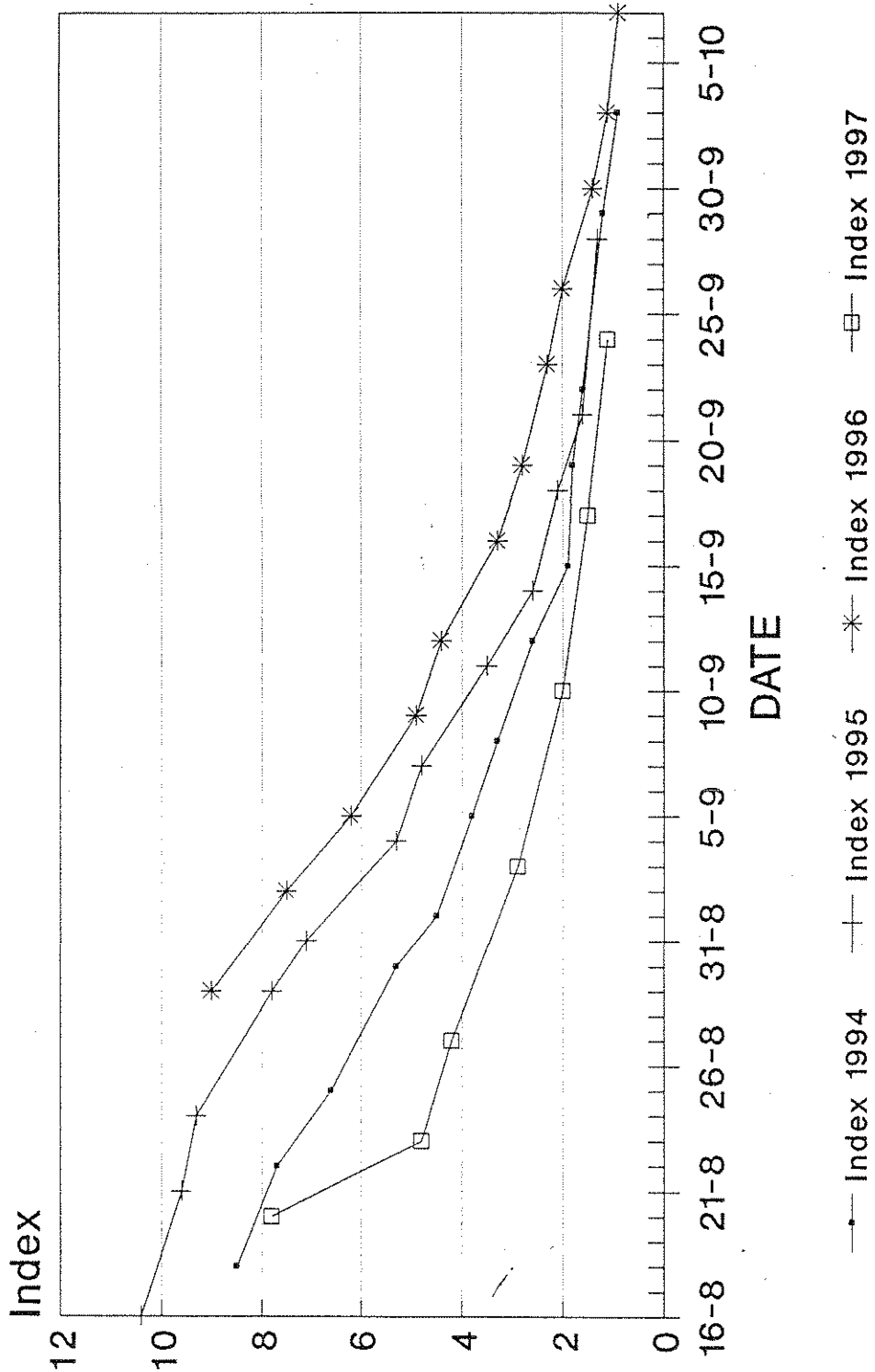


Figure 7

COUNTRY WIDE CONFERENCE 1997 FRUIT SIZE(mm)

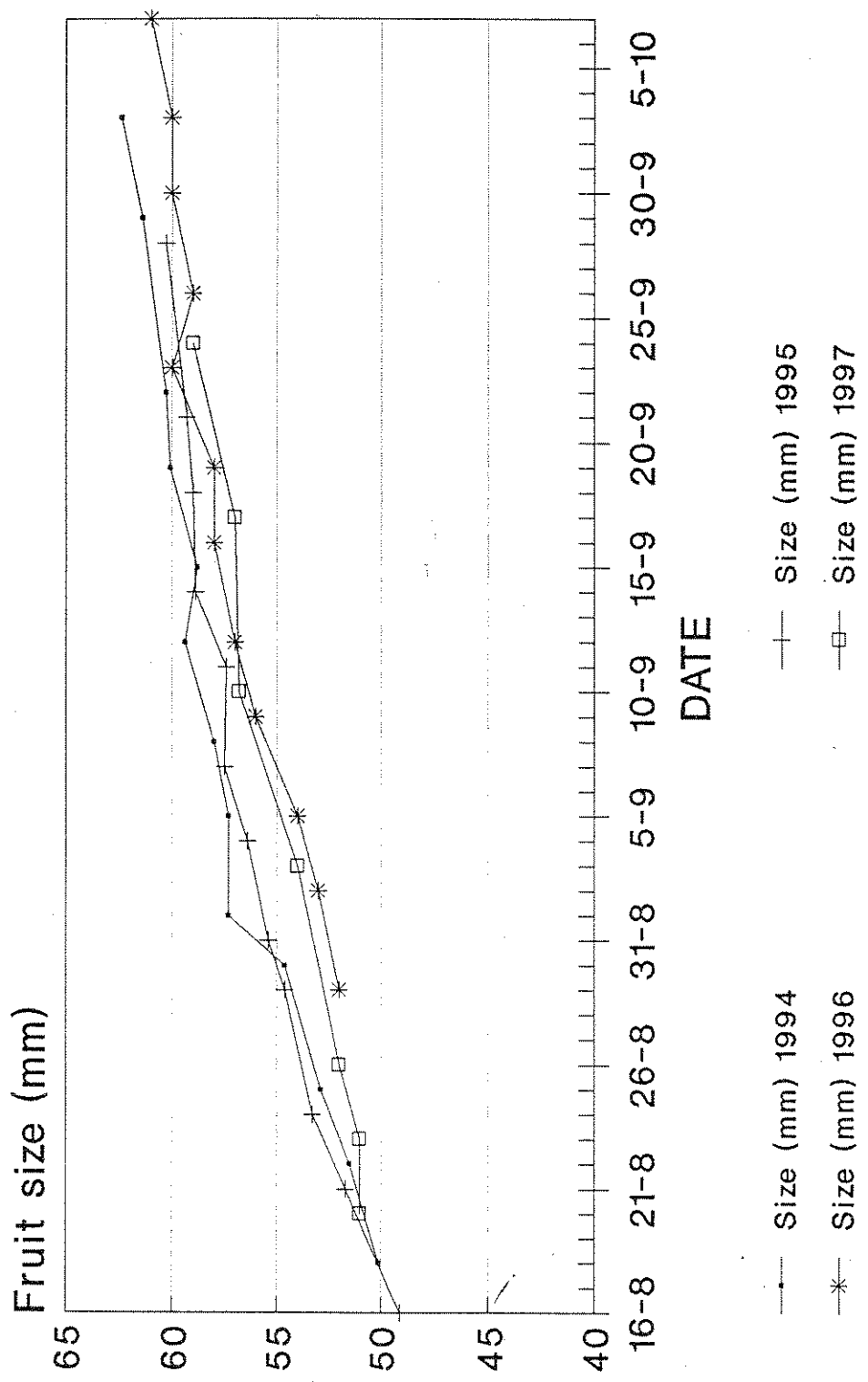


Figure 8

CALENDAR DATE AVERAGE STARCH PATTERN 70%				
Year	All Sites	Kent Sites	East Anglia Sites	West Midland Sites
1994	9/9	4/9	8/9	29/9
1995	14/9	13/9	12/9	N/A
1996	18/9	16/9	17/9	29/9
1997	7/9	31/9	4/9	16/9

As in previous seasons the maturity index did not show as large a variation between the sites as either the fruit firmness or starch pattern. This is due to the combination of three variable having a 'smoothing out' effect on the data.

Initially the index fell very rapidly between the 20th and 23rd August. It then reduced in rate to about 1 unit a week during the last week of August and the 1st week of September, this was about half the rate recorded in 1995 and 1996. As in the previous season the index flattened out at about 2 units (Figure 7).

On average the index reached 2.1 on the 8th September this was four or five days earlier than in 1994 and 1995 and almost two weeks earlier than the previous year. The Kent sites reached 2.1 at the beginning of September with East Anglia 3 days later and the West Midlands over two weeks later (Table 7).

TABLE 7. Date on which mean fruit index reached 2.1 at the average site in 1994, 95, 96,97 and for the average site in Kent, East Anglia and the West Midlands areas.

CALENDAR DATE AVERAGE INDEX REACHED 2.1				
Year	All Sites	Kent Sites	East Anglia Sites	West Midland Sites
1994	12/9	9/9	12/9	>3/10
1995	13/9	12/9	12/9	>28/9
1996	20/9	15/9	20/9	2/10
1997	8/9	2/9	5/9	18/9

2. Conference

Conference fruit size did not increase initially. However during the last week of August and first half of September fruit size increased by about 2 mm a week, after which time it slowed down to about 1 mm a week. Despite the light crops fruit size was similar to the previous year and 2.5 mm below that recorded in 1994 and 95. (Figure 8).

Initially soluble solids did not increase during August, then between 27th and 3rd September they increased by over 2%, they then continued to increase by about 0.1% a day for the rest of the study (figure 9) finishing up slightly above the 1994 and 1995 level.

Like Cox, average fruit firmness for Conference pears in 1997 was lower than in the previous season by about 0.5 - 1.0kg. During August fruit firmness fell by about 0.1kg a day, this was similar to the last three seasons rate of decline. From the beginning of September the rate dropped almost half, 0.05kg a day and thus by the end of the study fruit firmness was very similar to 1994 and 1995 (figure 10).

The maximum average starch pattern recorded during the study was just under 90% on the 20th of August. Starch pattern declined fairly steadily during the entire period of sampling at a rate of 2% a day, this was similar to previous seasons. (figure 11).

The index declined rapidly during August and the first week of September falling by almost 1.0 unit a week. From the 10th September the rate declined and an index of 1.0 was reached on the 14th September which fell to 0.7 by the 20th (Figure 12).

Using data from the five Conference pear sites the date on which the thresholds of a number of attributes was calculated and compared to previous seasons (Table 8).

TABLE 8. Date on which mean fruit size reached 55mm, firmness 6.0kg, starch pattern $\frac{2}{3}$ and $\frac{1}{3}$ of maximum and maturity index 1.0 and 0.7 at the average site in 1994, 1995, 1996 and 1997.

Year	CALENDAR DATE AVERAGE SITE REACHED					
	55mm Diam.	6.0kg Firm.	$\frac{2}{3}$ Starch	$\frac{1}{3}$ Starch	Index 1	Index 0.7
1994	30/8	17/9	8/9	18/9	5/9	17/9
1995	30/8	14/9	12/9	16/9	12/9	14/9
1996	4/9	24/9	7/9	19/9	9/9	16/9
1997	7/9	13/9	9/9	22/9	14/9	19/9

Fruit size reached 55mm on the 7th September at the average site in 1997, this was 3 days later than 1996 and over a week later than in 1994 and 1995. Fruit firmness fell to 6.0kg on the 13th September in 1997 this was similar to 1995, four days later than 1994 and a full 10 days later than last year.

Starch pattern fell to $\frac{2}{3}$ maximum by 9th September and $\frac{1}{3}$ maximum 13 days later on 22nd September, this was very similar to the previous three seasons.

The maturity index reached 1.0 on the 14th September and fell to 0.7 by 19th of September this was the latest date recorded in the four years of the maturity programme.

COUNTRY WIDE CONFERENCE 1997 SOLUBLE SOLIDS(%)

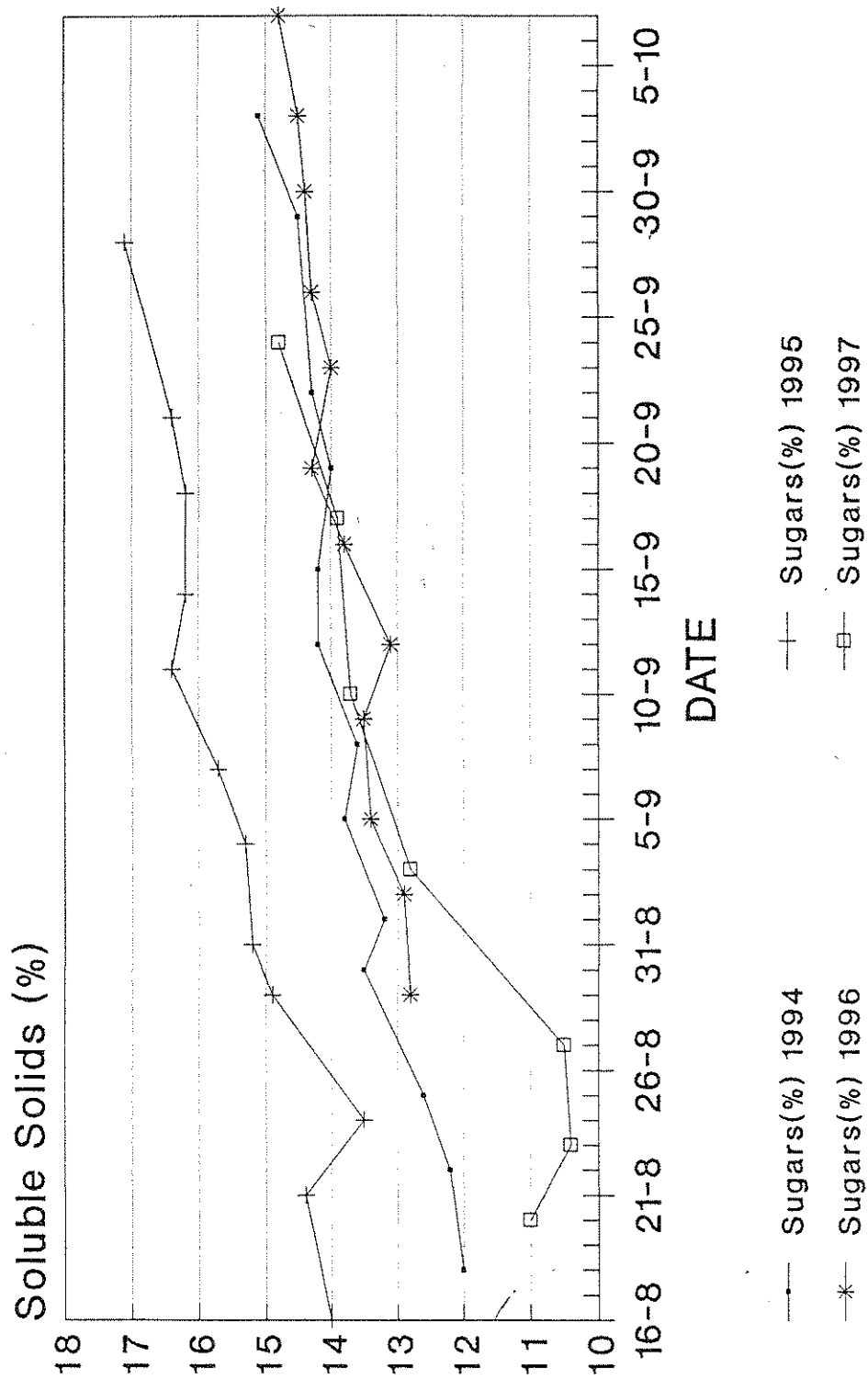


Figure 9

COUNTRY WIDE CONFERENCE 1997

Firmness (kg)

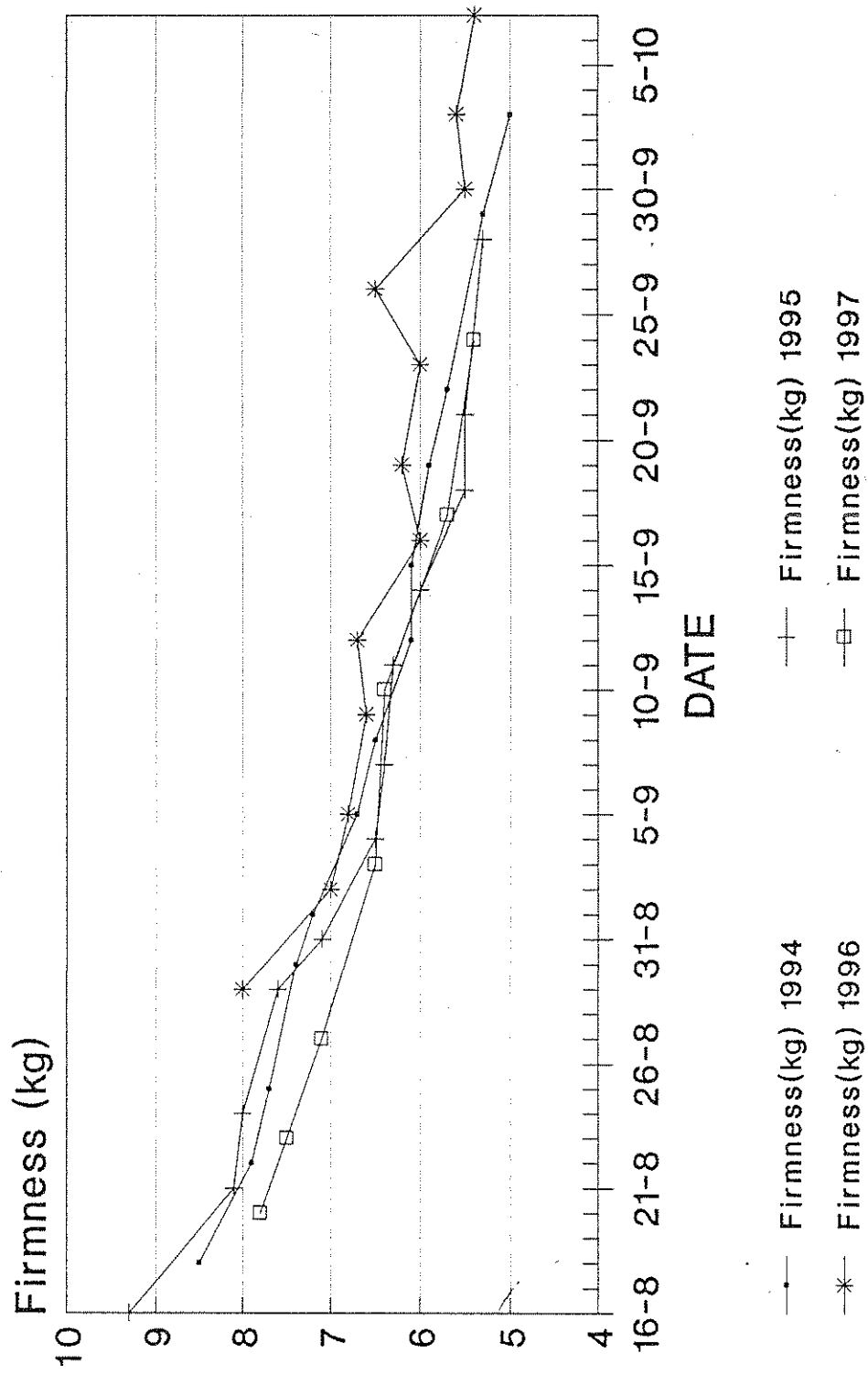


Figure 10

COUNTRY WIDE CONFERENCE 1997

Starch (%)

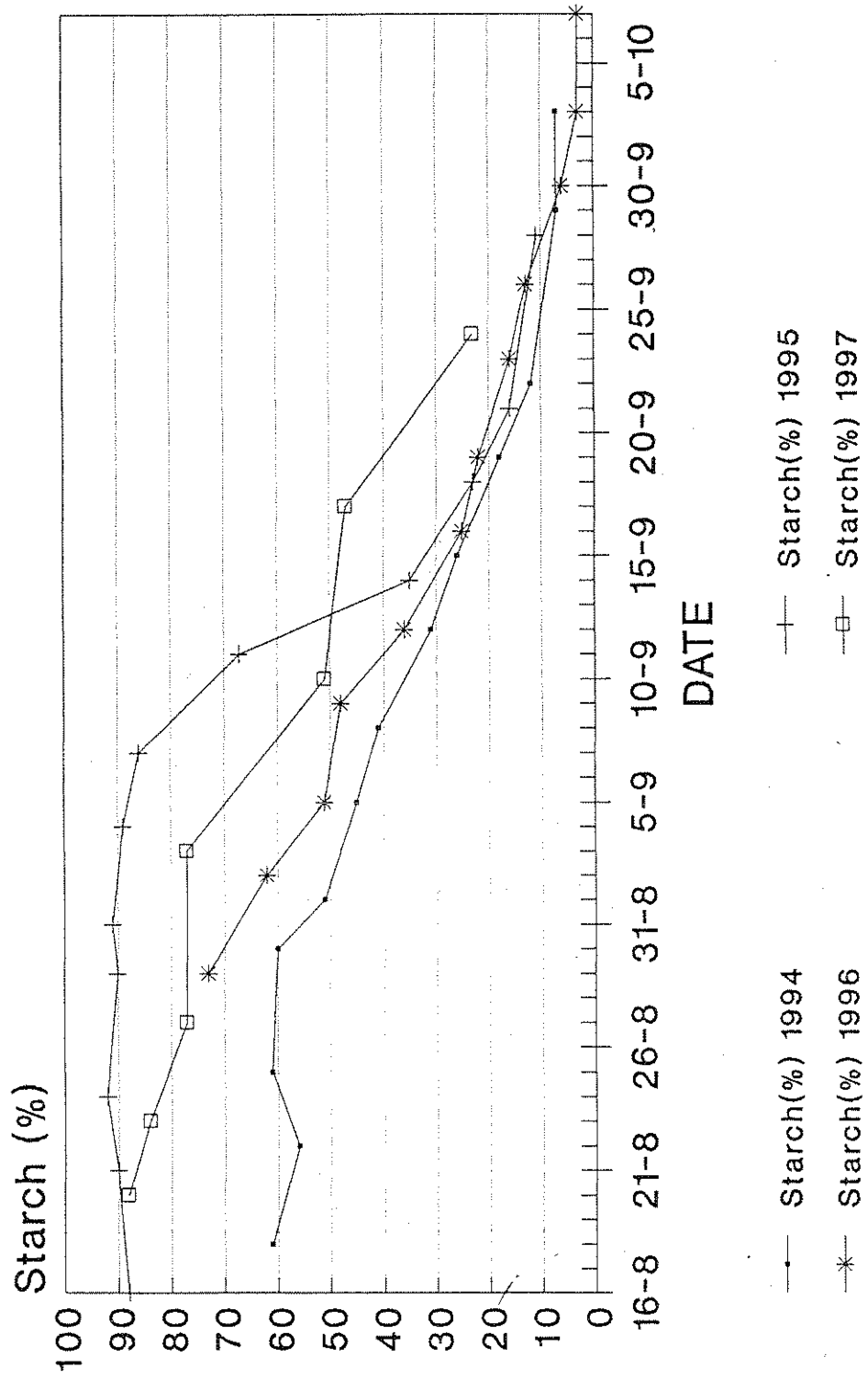


Figure 11

COUNTRY WIDE CONFERENCE 1997

Index

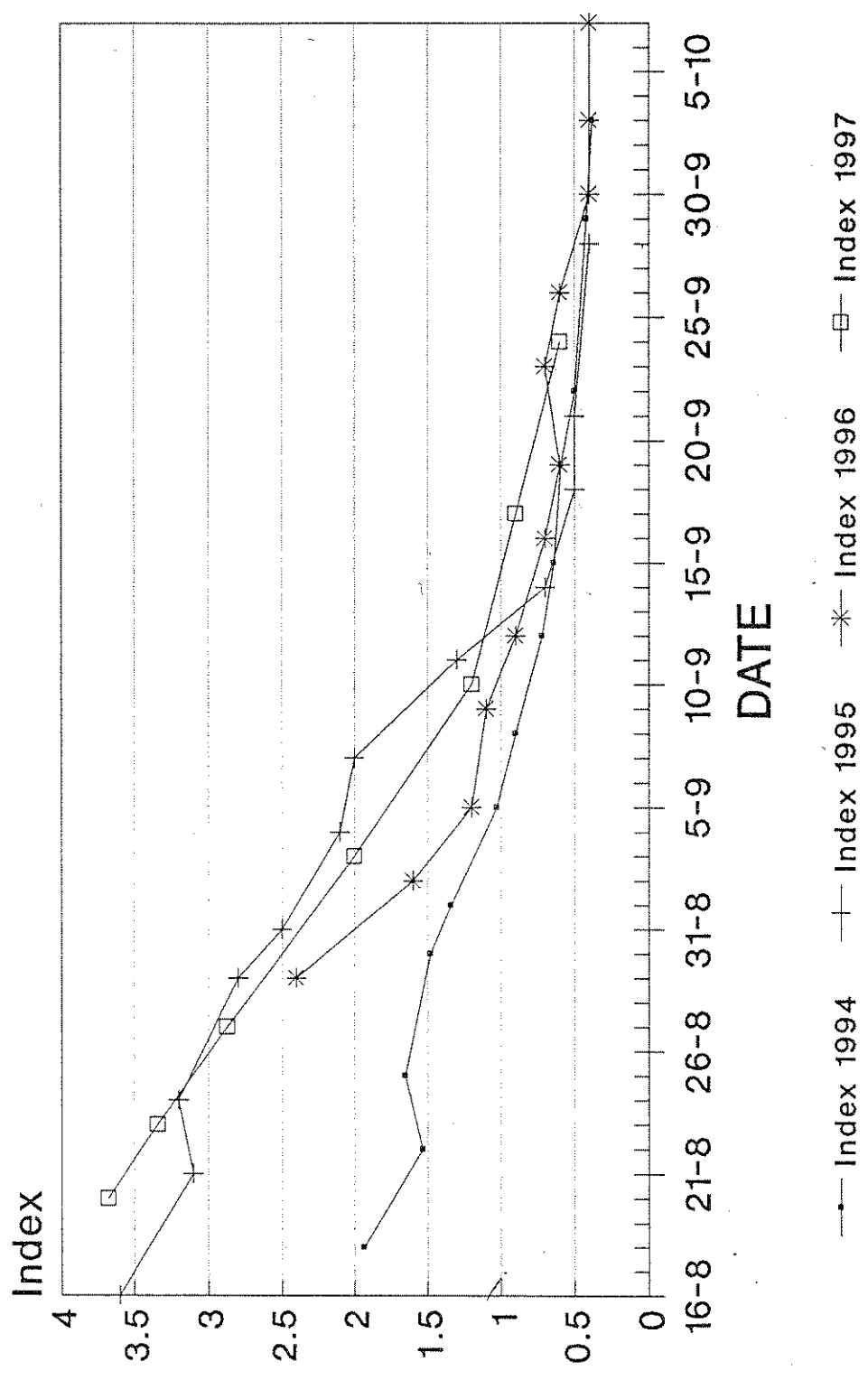


Figure 12

3. Cox Storage

A summary of the storage information obtained from the 1st inspection of fruit is shown in Table 9. Each figure is the mean of 20 apples from the site. After 20 weeks storage in $<1\%CO_2$ $1.2\%O_2$ $3.5^\circ C$ the average fruit firmness for fruit picked on the 3/9 and the 10/9 was above the threshold of 6.0kg required by most retail outlets. Of the ten sites in the study all had a firmness above 6.0kg after 20 weeks storage when picked on the 3/9/97. This was reduced to 7 sites when fruit was picked a week later on the 10/9/97. All the Kent sites were below 6.0kg when picked on the 17/9/97, or the 24/9/97 where as on both occasions the four East Anglian sites remained above 6.0kg there was little increase in the soluble solid content of the fruit with delayed harvest after 20 weeks storage. Background colour mellowed with delayed harvest and only fruit picked on the 3/9 or 10/9 meet the requirements of colour grade 2. All the samples showed very little internal disorders even after 10 days shelf life. The major cause of wastage was fungal spoilage which was between 2-4% initially, rising to 10% after a shelf life. There appeared to be little effect of delayed harvest on the amount of wastage due to rots.

Table 10 summarises the eating quality of the fruit from each harvest date after a 10 day shelf life. The results were obtained from measurements made by a single panellist. Both taste and aroma increased with delayed harvest but it was not until fruit picked on the 24/9 was there any significant effect on the latter. Texture was optimum on sample of fruit picked on the 10/9, later picked fruit showed a significant degree of softening as measured organoleptically.

Table 11 summarises the results obtained from fruit stored for 23 weeks in $<1\%CO_2$ $1.2\%O_2$ $3.5^\circ C$. Unfortunately the sample had to be moved from the original store to a store running at similar conditions due to commercial pressure. This move may explain the significant change in fruit firmness and level of rotting compared to fruit examined three weeks earlier.

As in early January only fruit picked on the 3/9 or the 10/9 had an average penetrometer reading above the 6.0kg required. Seven of the ten orchards had average firmness readings above 6.0kg when picked on the 3/9, this fell slightly to 6 sites when fruit was picked a week later on the 10/9. Only one East Anglian site had a firmness above 6.0kg when picked on the 17/9/97 and stored for 23 weeks.

There was no significant change in either sugar content or background colour of the fruit compared to the previous assessment. Once again there was a very low incidence of internal disorders and those present were confined to the last picked fruit at two sites after 10 days shelf life. However the level of rotting doubled both initially and after 10 days shelf life when 20% of the fruit was infected. As with the previous assessment there appeared little effect in delaying the harvest on the level of rotting.

Conclusion

The storage results presented here confirm the recommended picking dates produced by the Quality Fruit Group at the beginning of the 1997 harvest. However the Group could only make clear recommendation because of the data collected in late August.

Quality Fruit Group Storage results 1997/98

Table 9 - The effect of harvest date on the storage quality of Cox's Orange Pippin apples stored in 1.2% O₂ (<1%CO₂) at 3.5°C until early January (20 weeks) Figures in brackets refer to fruit kept in air at 18°C for a further 10 days to simulate marketing.

Harvest date	Firmness	Sugar	Colour	Rots
03/09/97	6.8	15.2	1.5	1.5 (9.0)
10/09/97	6.6	15.2	1.7	4.0 (9.0)
17/09/97	5.8	15.4	2.3	2.2 (10.0)
24/09/97	5.9	15.6	2.8	4.0 (4.0)

Footnotes

1. ENFRU colour card 1 = green 4 = yellow colour grade 2 optimum for marketing.
2. Firmness measured using a Effigi penetrometer fitted in a drill stand.
3. Sugar measured using a refractometer.

**Quality Fruit Group
Storage results 1997/98**

Table 10 The effect of harvest date on the eating quality of Cox's Orange Pippin apples stored in 1.2%O₂ (<1% CO₂) at until early January and in air at 18°C for 10 days.

Harvest date	Texture	Taste	Aroma
03/09/97	4.7	3.4	1.8
10/09/97	5.0	3.9	2.9
17/09/97	6.2	4.7	3.4
24/09/97	6.9	4.9	4.9

1. Taste assessment carried out by John Chapman of FAST Ltd
2. Scale 0 - 10 with 5 as optimum

**Quality Fruit Group
Storage results 1997/98**

Table 11 The effect of harvest date on the storage quality of Cox's Orange Pippin apples stored in 1.2% O₂ (< 1% CO₂ at 3.5°C until early February. Figures in brackets refer to fruit kept in air at 18°C for a further 10 days to simulate marketing.

Harvest date	Firmness	Sugar	Colour	Rots
03/09/97	6.2	15.3	1.9	4.5 (18.0)
10/09/97	6.1	15.5	2.1	6.5 (20.5)
17/09/97	5.5	15.7	2.1	2.0 (17.0)
24/09/97	5.6	16.0	2.3	2.5 (13.0)

Footnote

1. ENFRU colour card 1 = green 4 = yellow colour grade 2 optimum for marketing.
2. Firmness measured using a Effigi penetrometer fitted in a drill stand.
3. Sugar measured using a refractometer.

The striking feature of the 1997 Cox crop was the low fruit firmness and the early fall in starch pattern compared to the previous three seasons. The first measurements made on the 20th August indicated that fruit firmness was about 2kg lower than previously recorded and that starch pattern was a week in advance of that recorded in 1995 or 1996.

Initially it had been proposed to carry out sampling once a week, however the implication of the first results were of such significance that an additional sample was taken on Saturday 23rd August. This allowed the Quality Fruit Group to have the results from three sampling occasions when they met on Thursday 29th August.

It is clear the information on fruit quality provided by the study is invaluable to the process of producing harvest dates and gives the marketers a clear guide to the forthcoming quality of the crop.

Once again the work has highlighted the tremendous range in maturity dates between sites and the results demonstrated clearly that this range was reflected on the performance of fruit in ultra low oxygen storage. Unfortunately the variability in fruit maturity between orchards cannot be explained by one or two orchard facts. Sites that were selected as being late based on three years experience, in 1997 became the first to mature. One of the historic 'early' sites was in 1997 one of the last ones to mature.

The storage results showed that for fruit to have a satisfactory texture after 20 weeks in ultra low oxygen it has to have a harvest firmness in excess of 8.0kg. The use of ultra low oxygen together with a better understanding of mineral nutrition has reduced the occurrence of traditional storage disorders. The major cause of wastage in this study was by fungal pathogens.

MATERIALS and METHOD

Thirty pounds of Conference pears picked on the 3rd, 10th, 17th and 24th September were held in a commercial fruit store at -0.5 to -1.0°C in air. Samples were removed from the store on 15th May and were transferred to a ripening room at 18°C. Penetrometer measurements (8mm probe) were made on opposite sides of 5 fruits after 0 and 4 days at 18°C. The samples were then cut longitudinally and examined for the presence of physiological disorders.

RESULTS

Conference pears

May - air storage followed by 7 days at 18°C. The storage results for all five orchards in the study are presented in Annexe 5. This provides the opportunity for participating growers to examine the effects of harvest date on the storage behaviour of fruit from their own orchards.

Generally there is little influence of pre-harvest factors on the storage quality of Conference pears. Correct harvest date combined with storage practice should ensure satisfactory quality over the recommended duration of storage. Optimum harvest date (OHD) is considered to be that which provides the following.

- A minimum ex-store firmness of 4kg to avoid damage during mechanical grading and marketing.
- minimal rotting.
- freedom from physiological disorders senescent breakdown.
- maximum eating quality - normally achieved by delaying harvesting as long as possible.

In 1997, the correct harvesting dates determined by measurements made on samples picked on the 3rd, 10th, 17th and 24th September and stored in a commercial fruit store at -0.5 to -1°C coincided with the dates suggested by the QFG of the 3rd to 13th September.

The average data from the five orchards presented in Table 9 clearly shows that the picking date satisfied all the quality criteria listed above was 3rd to 10th September; this endorses the advice given by the QFG at the beginning of September. Fruit picked on the third occasion although on average had sufficient firmness ex-store was starting to show signs of internal breakdown. The concentrations of soluble solids in fruit from all picking dates were sufficiently high to provide good eating quality.

The data in Table 10 indicate, for each orchard, the harvest (1, 2, 3 or 4 corresponding to 3, 10, 17 and 24th Sept) which achieved specific quality criteria and the 'streif' index associated with that harvest date. Results from the first three years of the programme had confirmed that the OHD for the storage of Conference pears conformed to a 'Streif' index of 0.7 and it has been recommended that harvesting should proceed at an index value of 1.0 and conclude at 0.8. This would normally

provide only a week of picking for long term storage. The results shown on Table 10 confirmed that harvesting Conference pears when the 'Streif' index was on average above 0.8 provided fruit of the required firmness ex-store and the fruit ripened in 4 days at 18°C without breakdown. The fact that all five sites had soluble solid levels above 12% at pick one, where the 'Streif' index was on average above 2.0, indicates that picking for long term storage could start before the index reached 1.0 and still provide fruit of good eating quality.

Thus picking for long term storage should start as soon as fruit has sufficient size and the average soluble solids are above 12% and must be concluded before the index falls below 0.8, where fruit is to be stored long term in air at -0.5 to -1.0°C.

TABLE 9

Storage quality of Conference pears stored in air at -0.5 to -1.0°C until 15th May 1998. (Data are means of 5 orchards)

	Picking Date			
	3/7	10/7	17/7	24/7
Firmness kg				
Day 0 @ 18°C	5.2	5.1	4.8	3.0
Day 4 @ 18°C	1.0	1.3	1.1	1.2
% Breakdown	0	0	7	71
% SS	12.0	13.1	13.3	14.3

1. Harvesting window - suggested commercial picking period in 1997 was 3-13 September.
2. % breakdown relates to pears ripened at 18°C.
3. SS + % soluble solids at harvest.

TABLE 10

Harvest date associated with quality criteria for Conference pears in 1997. Streif index at harvest is given in brackets.

Orchard	achieve 4kg ex-store firmness	avoid breakdown	12% SS achieved
Scripps, Hononton	3 (0.8)	3 (0.8)	1 (1.8)
Mitchell	3 (0.9)	3 (0.9)	1 (1.7)
Redsell	3 (0.8)	2 (0.8)	1 (2.4)
Feltons	3 (0.9)	3 (0.9)	1 (2.9)
Highland Court	3 (1.0)	3 (1.0)	1 (2.0)

Footnotes

1. Picks 1, 2, 3 and 4 were on 3, 10, 17 and 24th September.
2. SS = soluble solids at harvest.
3. Streif index: firmness (N) 1 starch index * % SS.
4. Fruit firmness should be 4kg minimum ex-store.

ANNEXE 5

Storage quality of Conference pears stored in air at -0.5 to -1.0°C until 15 May 1998 for each of the five individual sites.

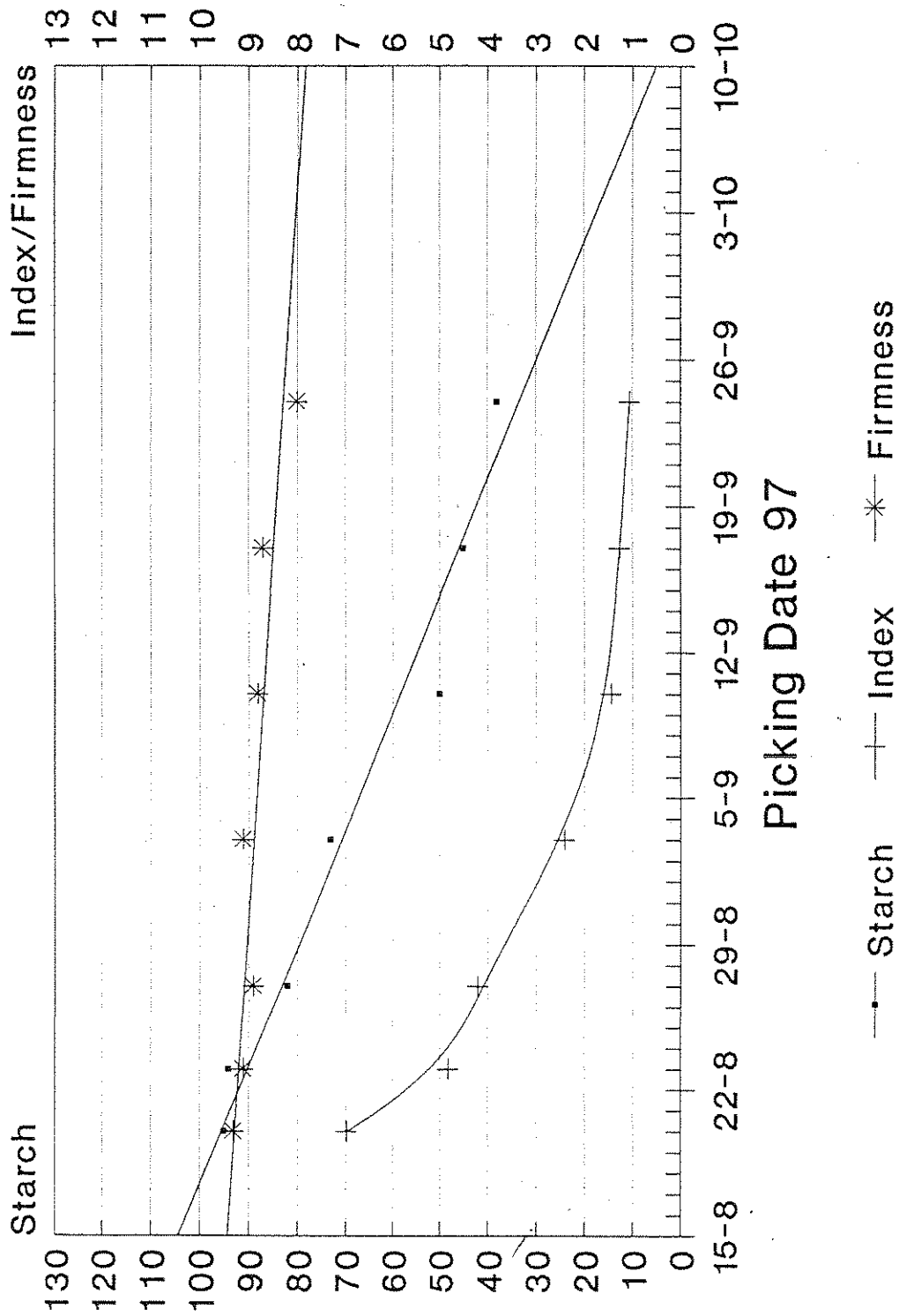
HARVEST DATE

SITE	DAYS at 18°C	3/7		10/7		17/7		24/7	
		FIRM Kg	BREAK %	FIRM Kg	BREAK %	FIRM Kg	BREAK %	FIRM Kg	BREAK %
Mitchell	0	5.7	0	5.6	0	5.0	0	3.7	100
	3	1.1	0	1.4	0	1.2	0	1.3	80
	7	-	0	-	0	-	0	-	40
Highland	0	5.3	0	5.2	0	4.4	0	2.8	80
	3	0.9	0	1.5	0	1.1	0	1.4	40
	7	-	0	-	0	-	0	-	60
Redsell	0	5.3	0	4.9	0	4.6	40	2.5	100
	3	1.0	0	1.2	0	1.0	20	1.0	60
	7	-	0	-	0	-	40	-	40
Feltons	0	-	-	-	-	4.4	0	2.5	100
	3	-	-	-	-	0.9	0	1.2	80
	7	-	-	-	-	-	0	-	100
Scripps	0	4.8	0	4.7	0	5.4	0	3.4	80
	3	1.1	0	1.0	0	1.2	0	1.1	60
	7	-	0	-	0	-	0	-	40

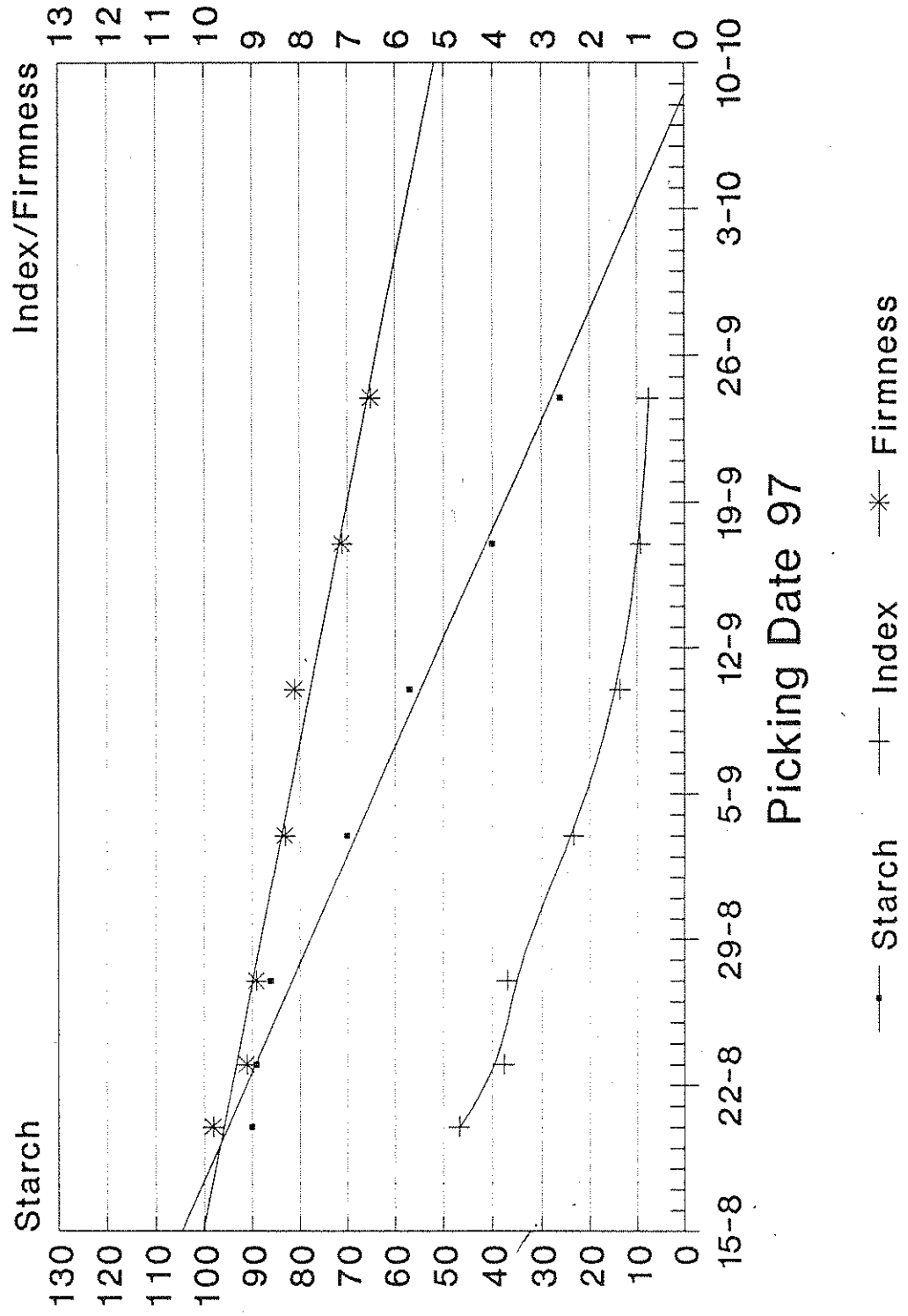
APPENDIX 1

**Graphs of fruit firmness, starch pattern
and maturity index with time for each
of the 15 Cox orchards**

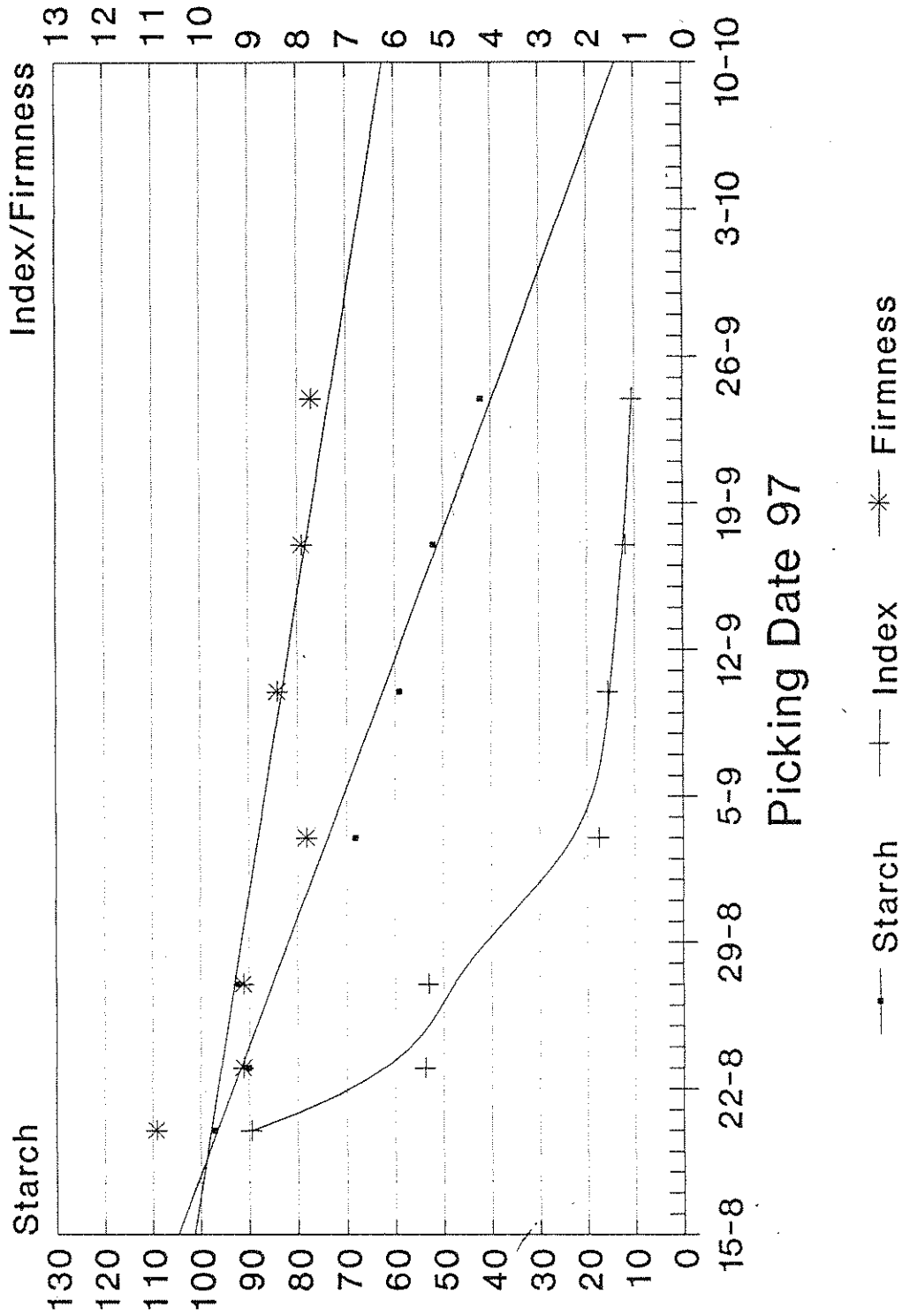
Otterham Quay Adams MM106 (K1)



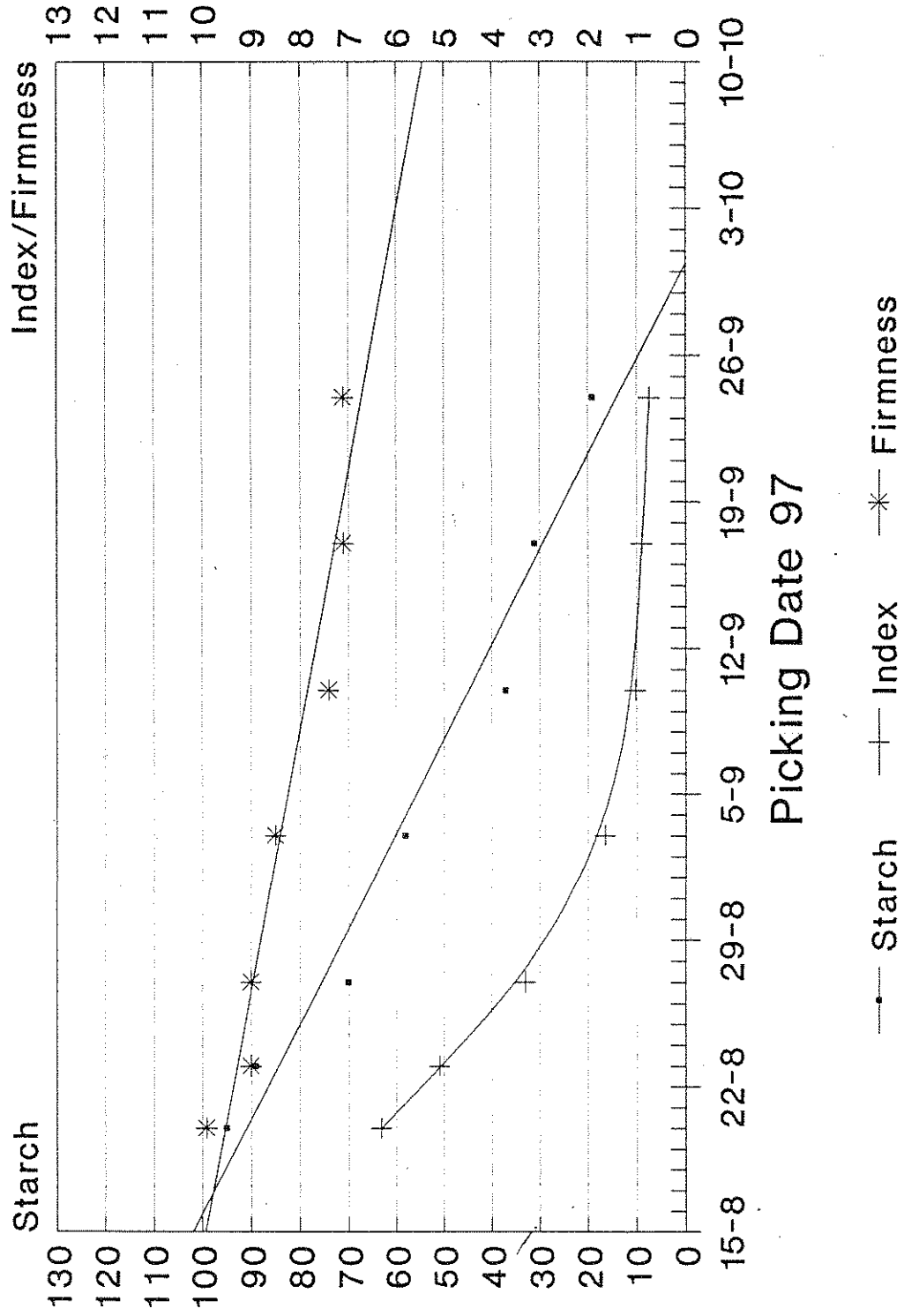
Goldstone Potts Cox MM106 (K3)



Monks Farm A 19 Cox M9(K7)

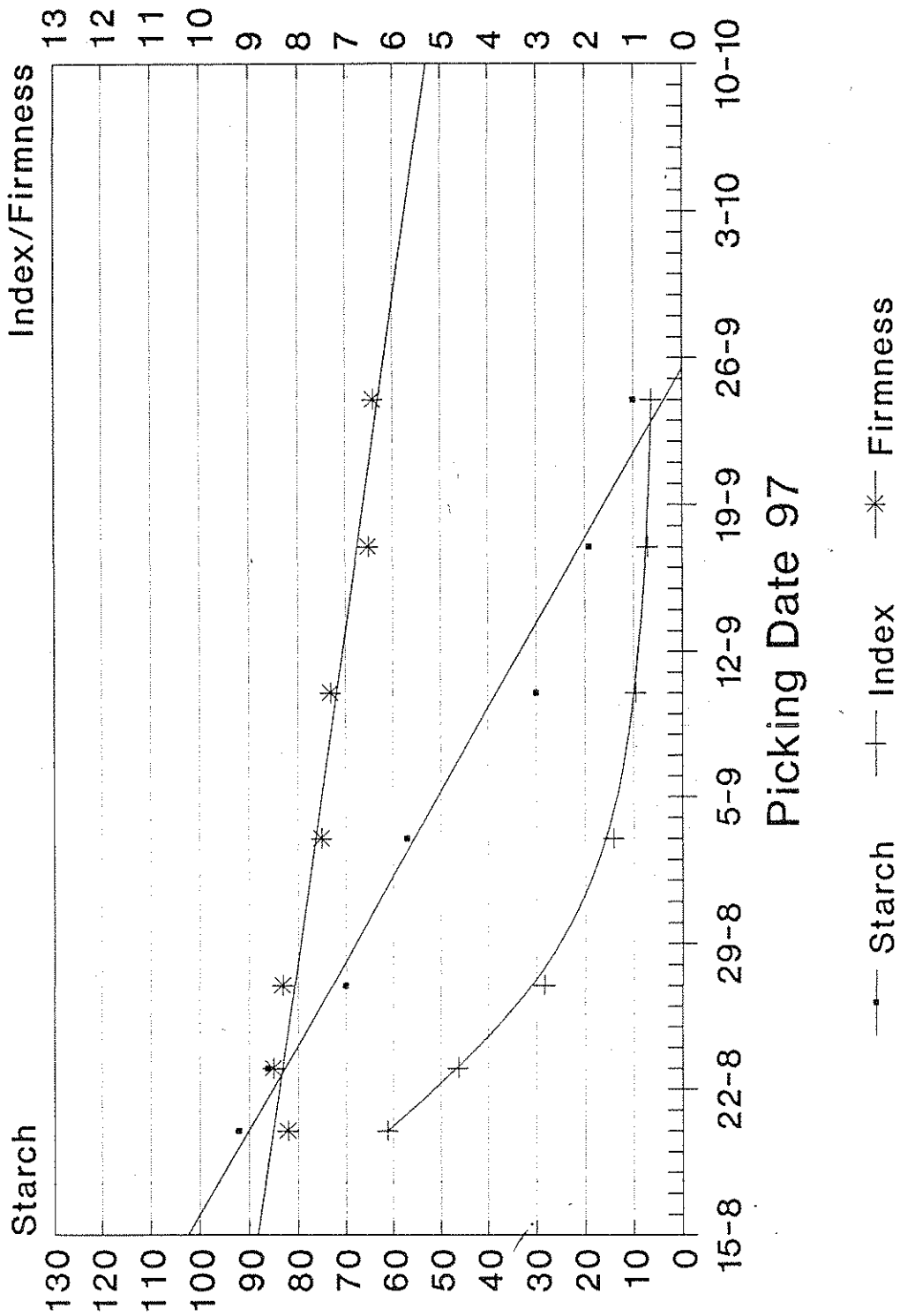


Broadfield Farm 'Jubilee' MM106 (K10)

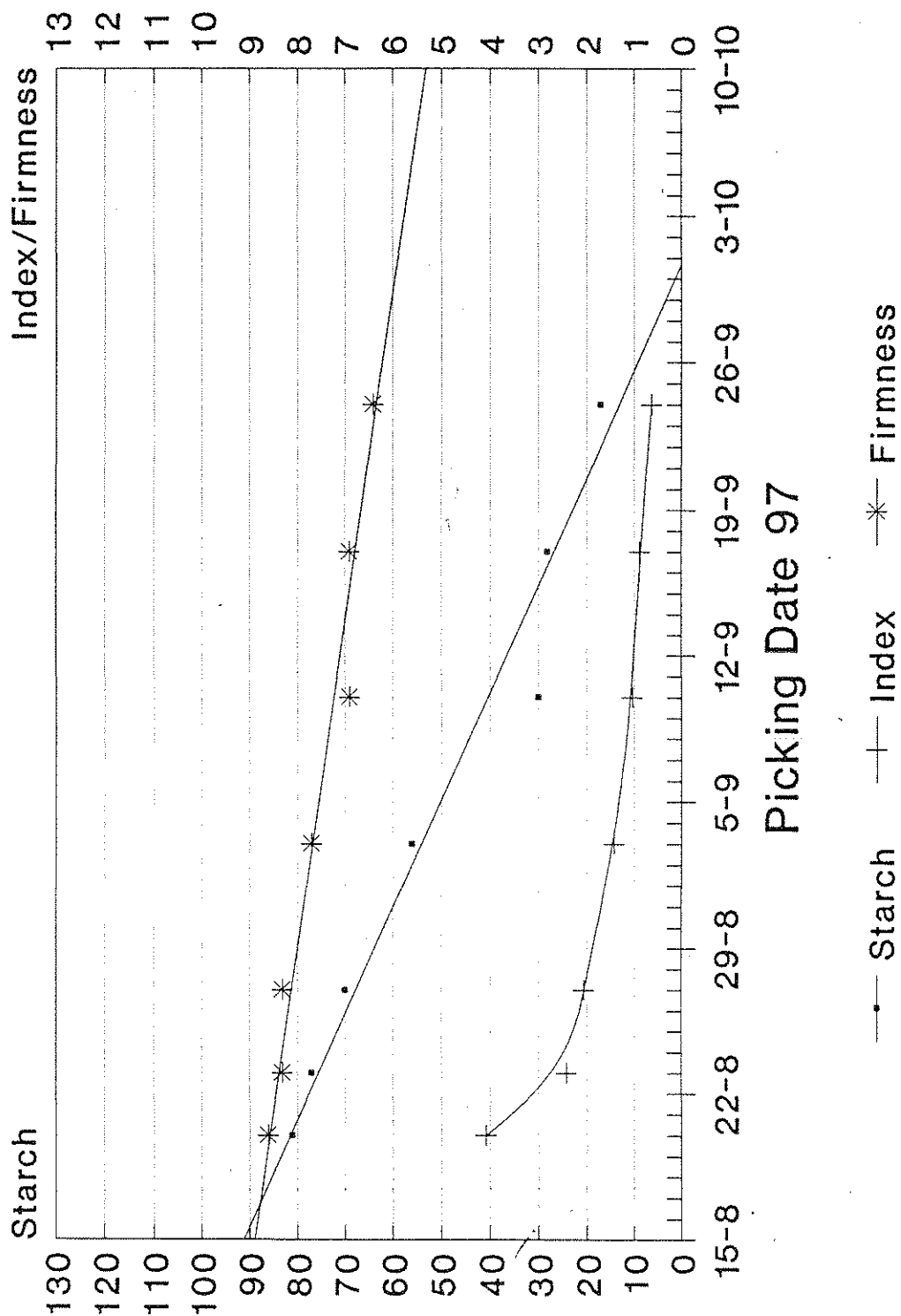


Picking Date 97

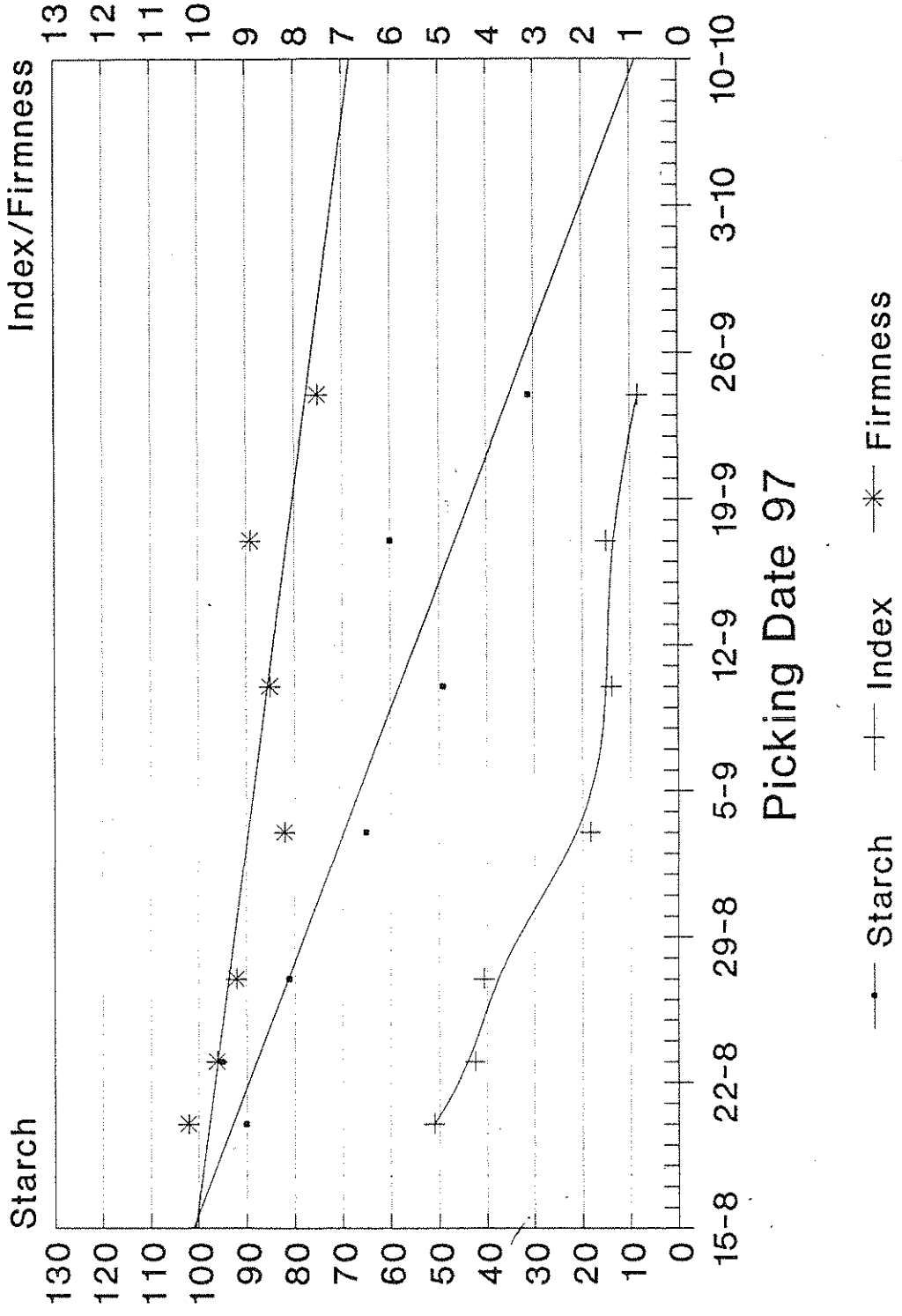
Wares Farm Maytums Cox M9 (K11)



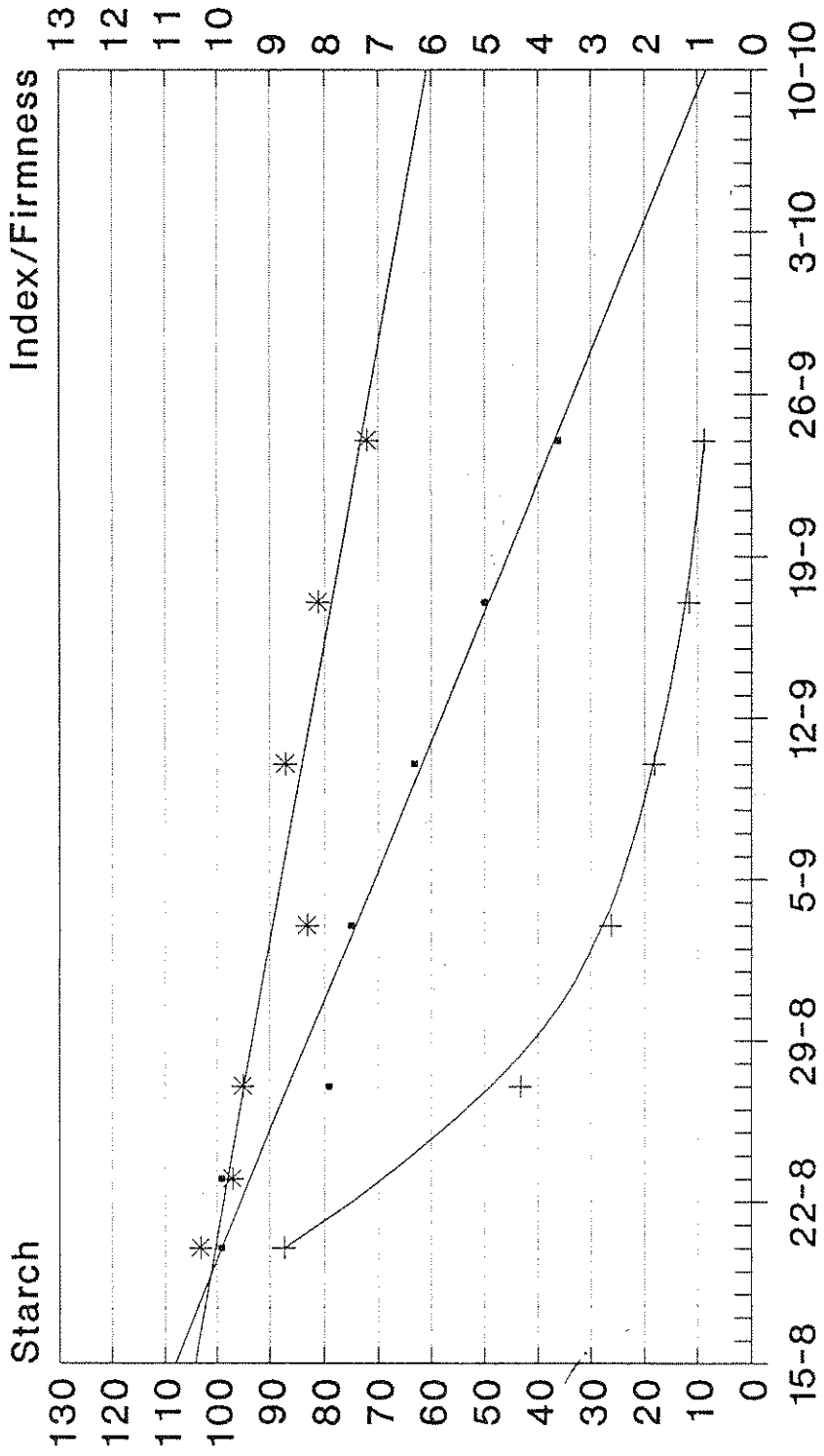
Wares Farm Cobblers Cox M9 4RB (K12)



Plains Farm Q Orchard M9 (E4)



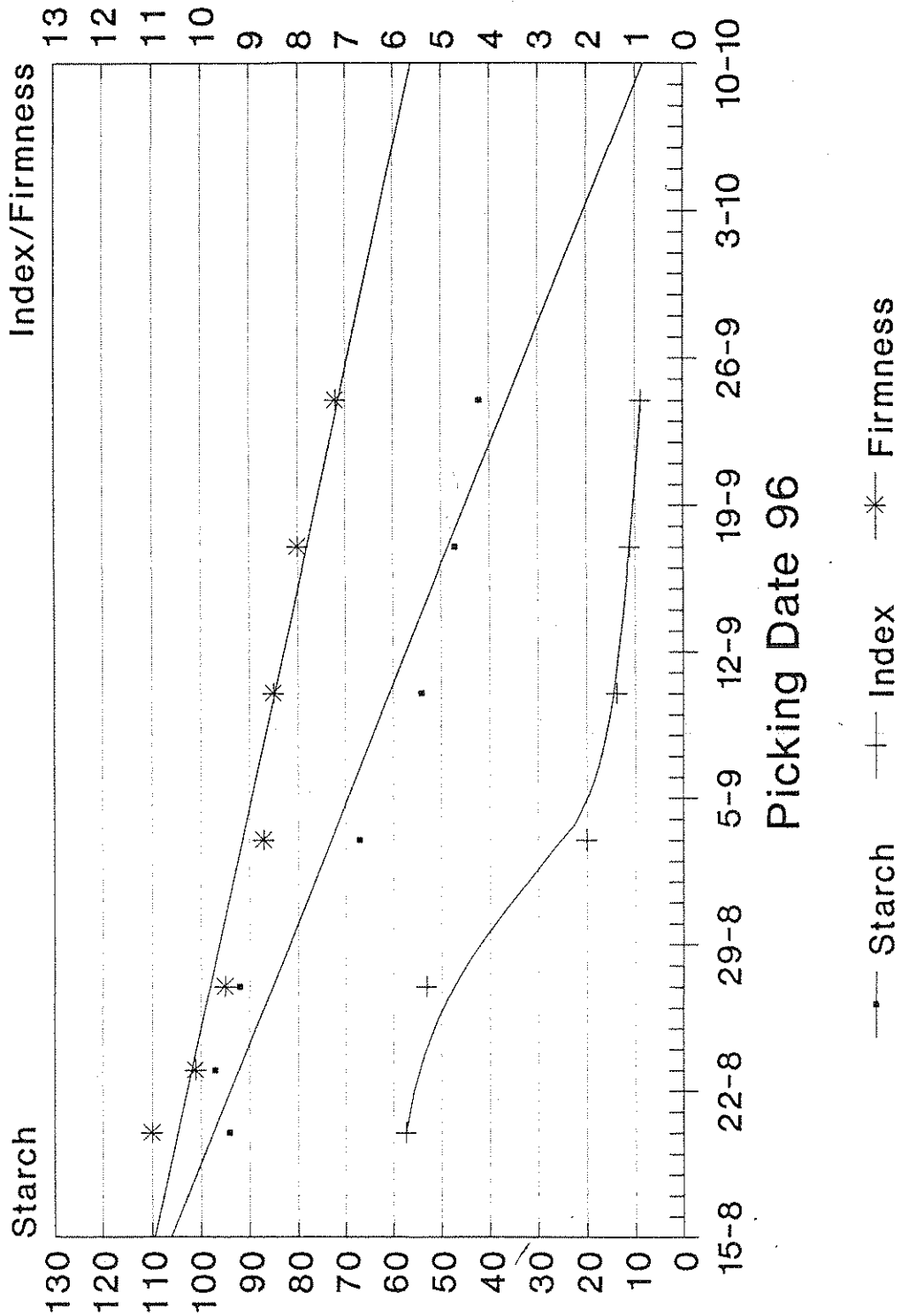
Feltons Farm Horseshoes Cox M9 (SF2)



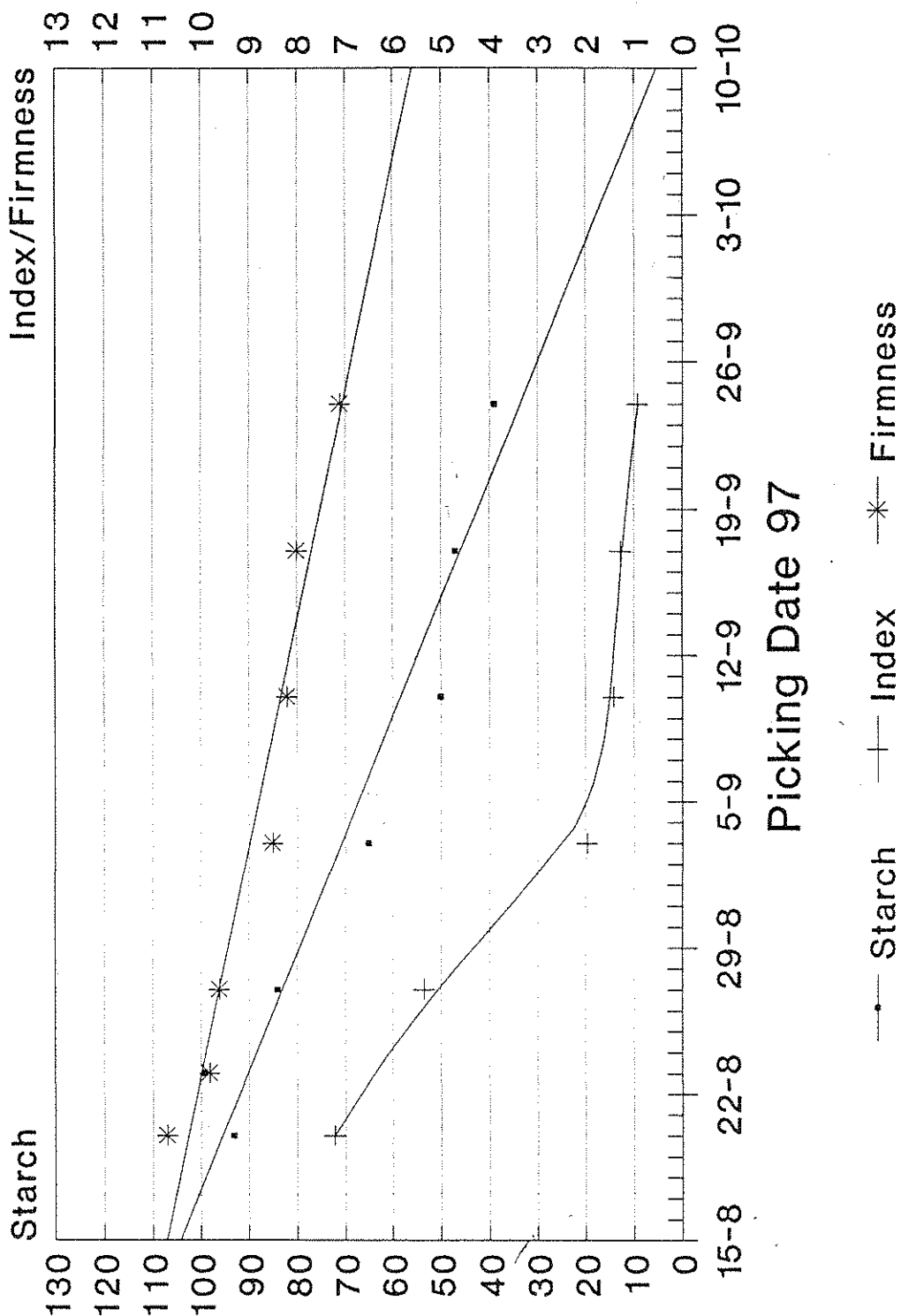
Picking Date 97

—+— Starch —+— Index —*— Firmness

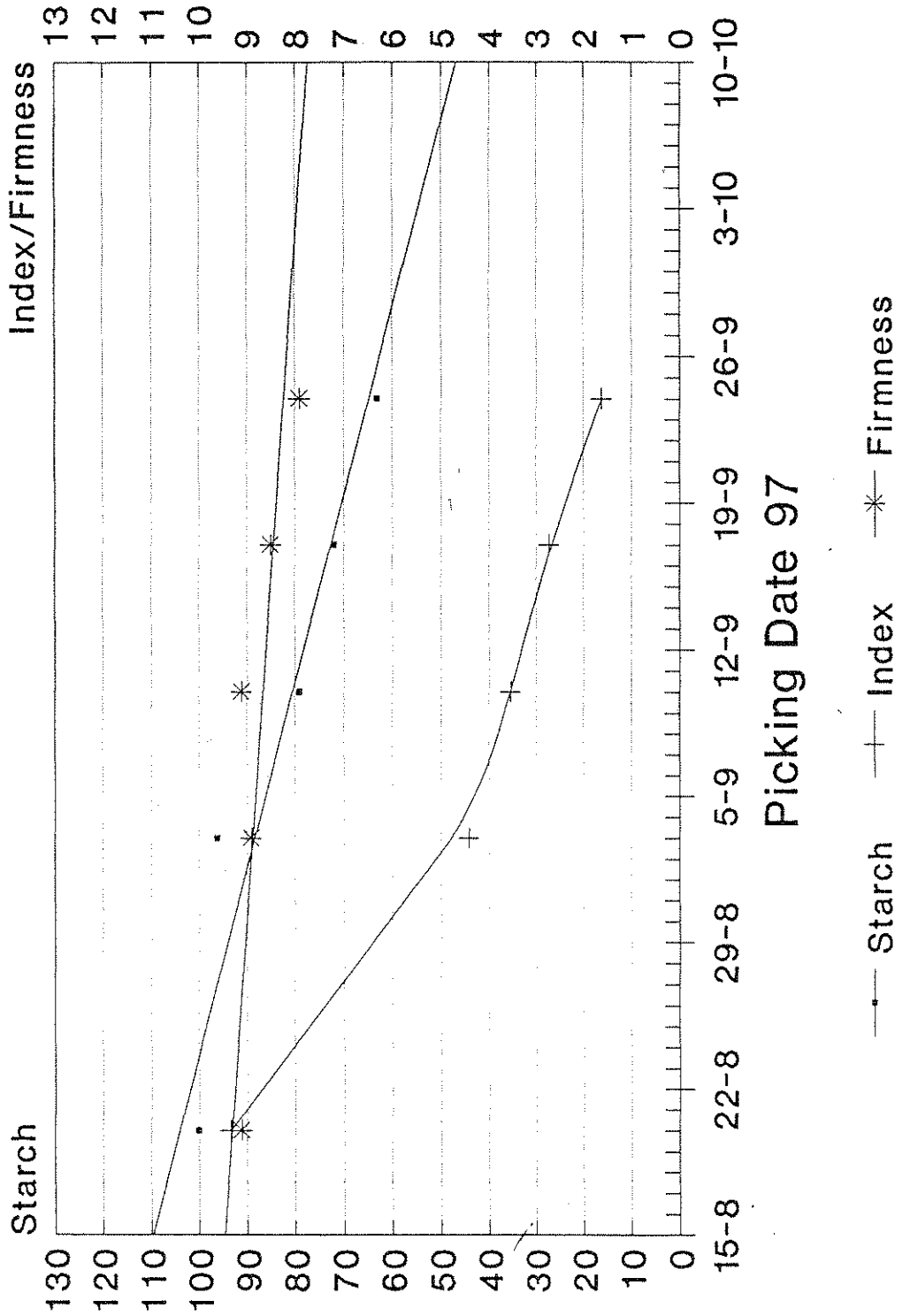
Charity Farm Flint Cox M9 (SF5)



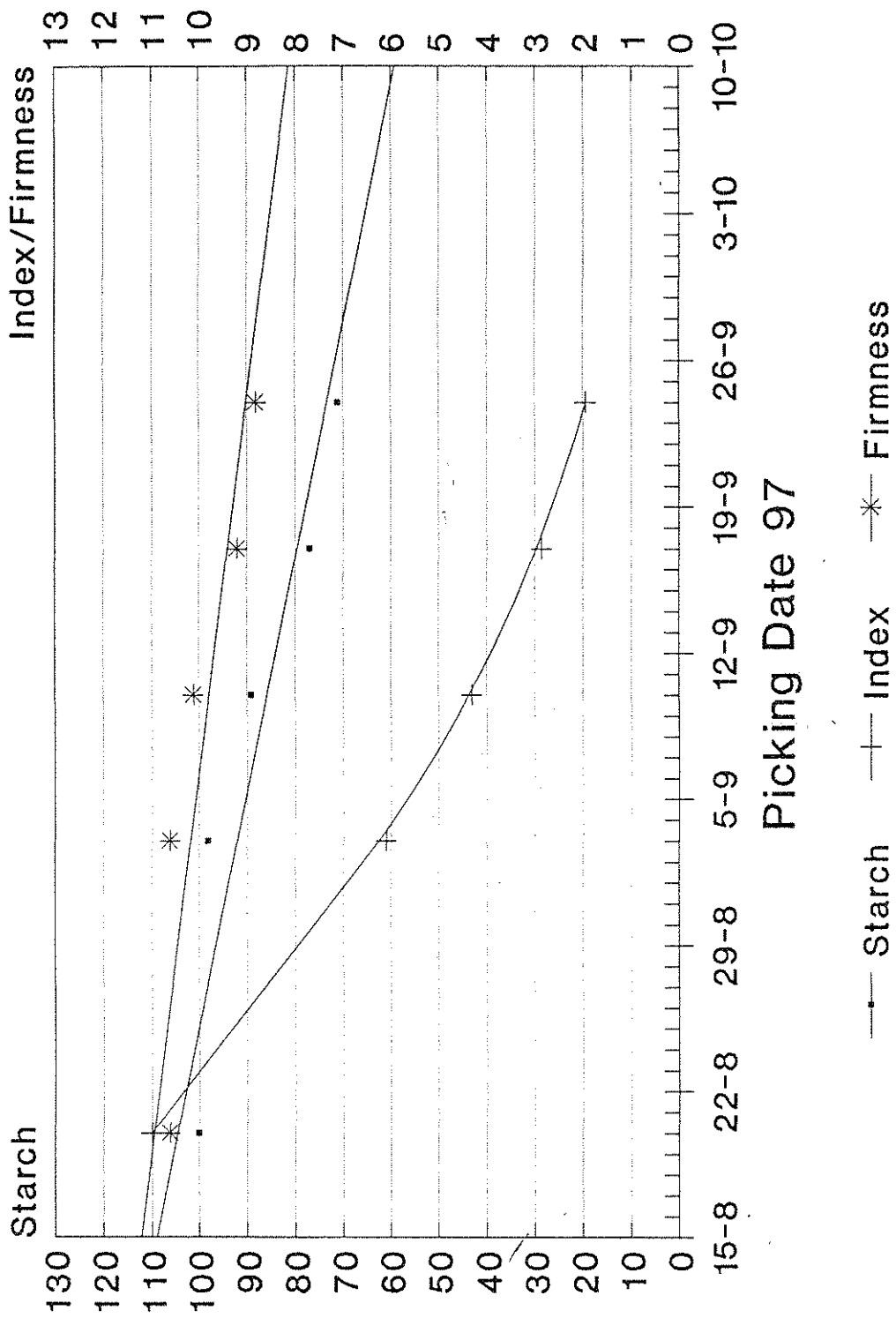
Ranworth Farm N Lodge East M9 (N3)



Mill Orchards Home Orchard B MM106 (WM3)

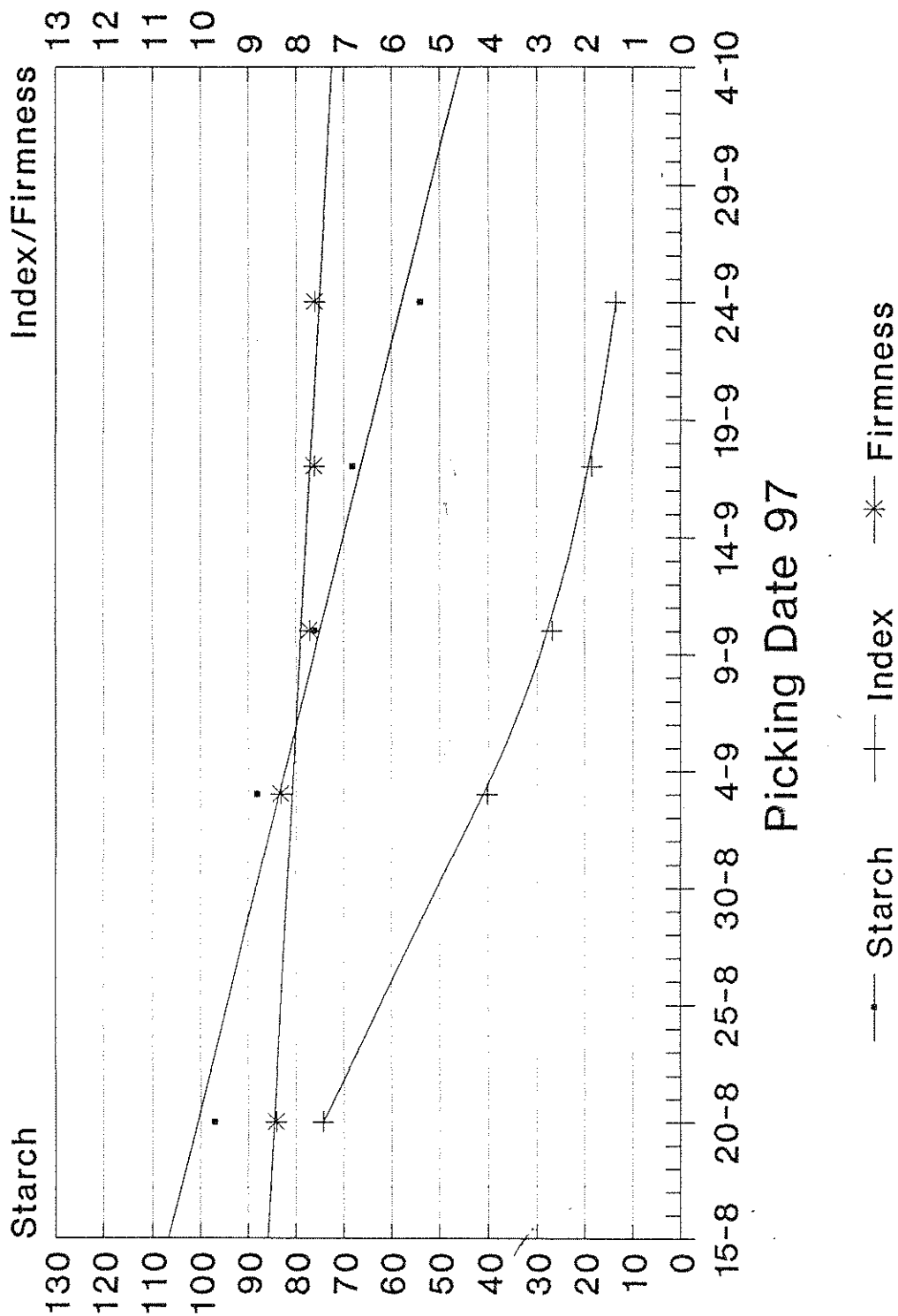


Mill Orchards Cox 88 A MM106 (WM4)



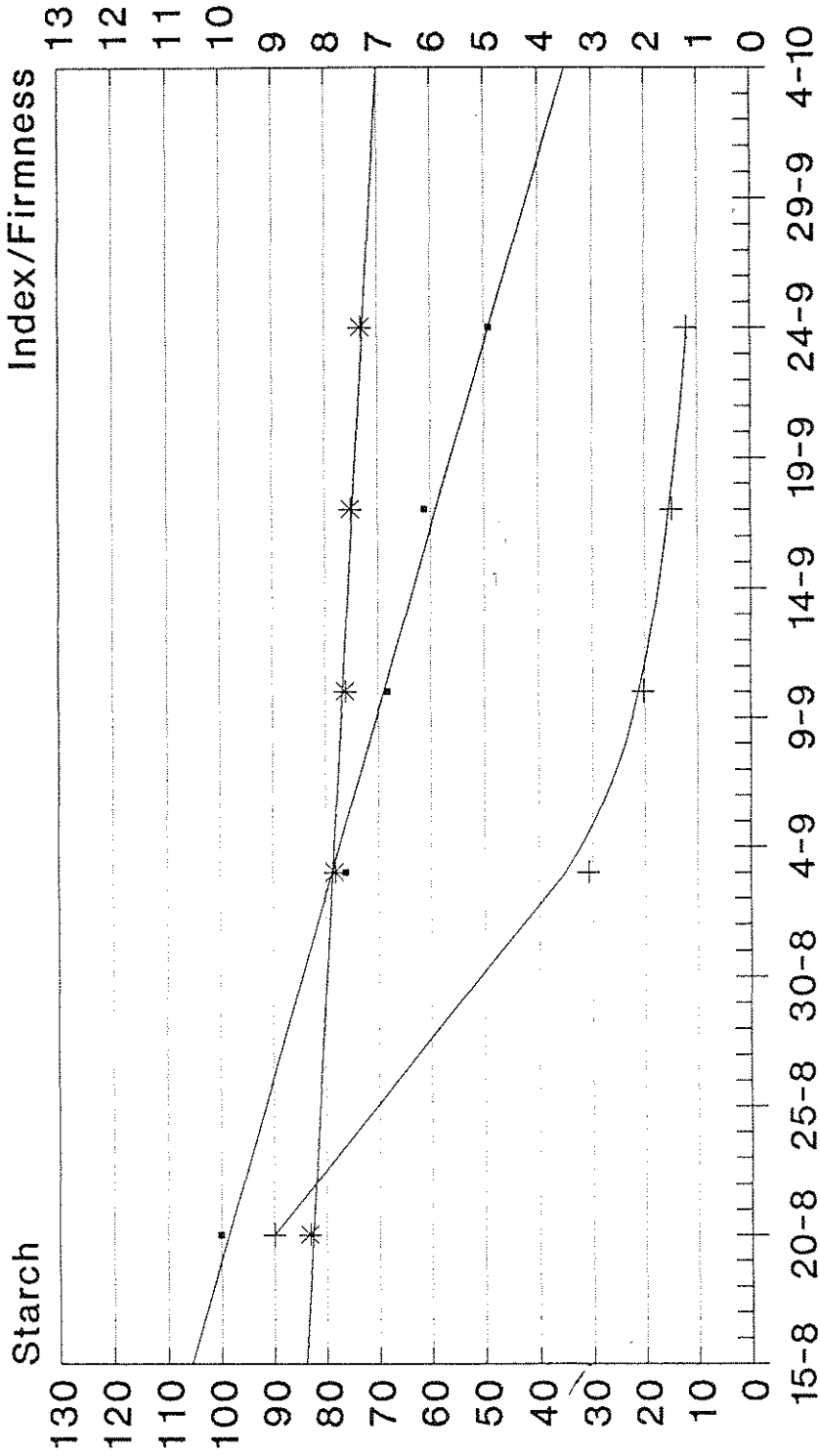
Picking Date 97

Osborne Barnfield E Cox M9 (WM5)



Picking Date 97

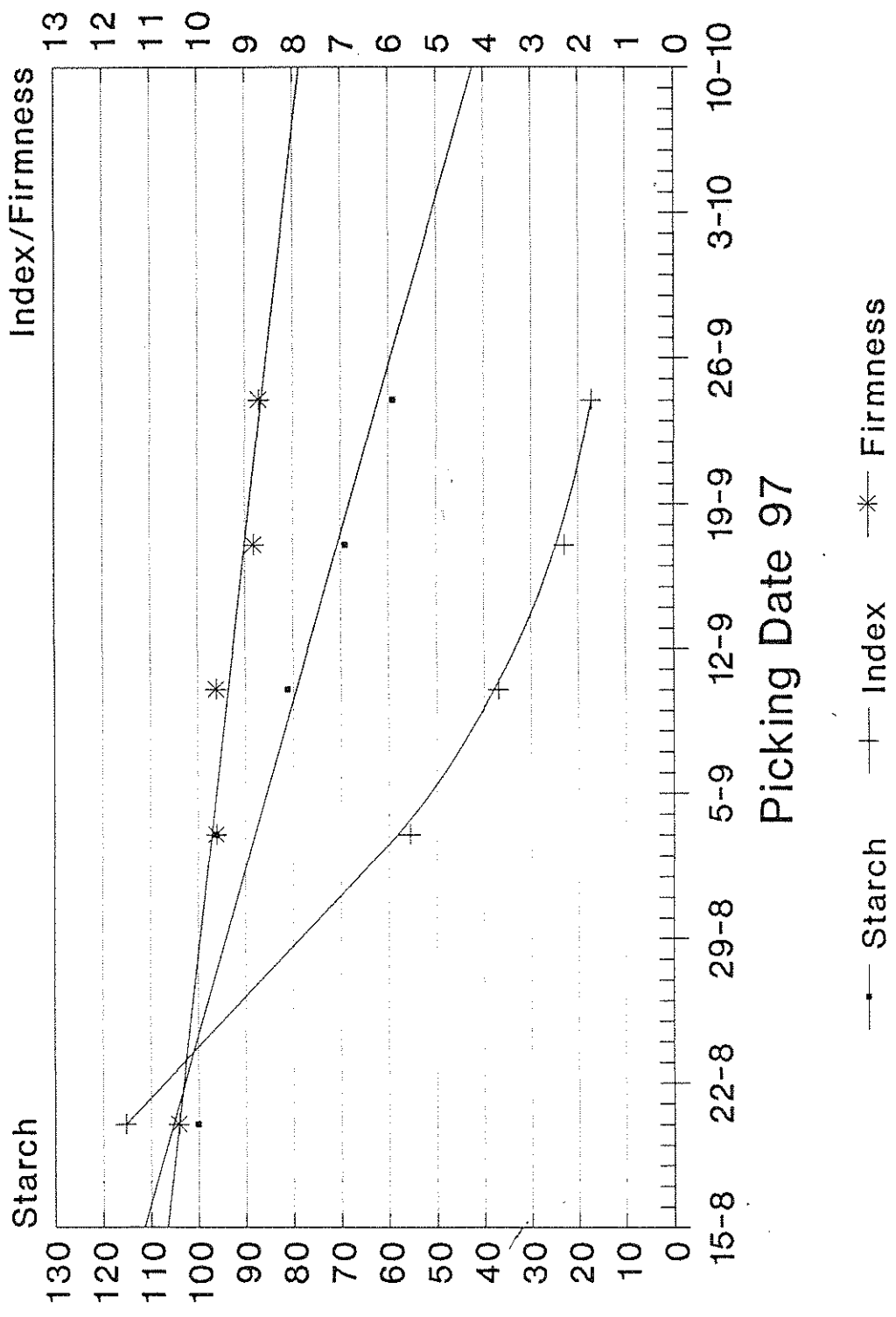
Osborne Housefield Cox M26(WM6)



Picking Date 97

—•— Starch —+— Index —*— Firmness

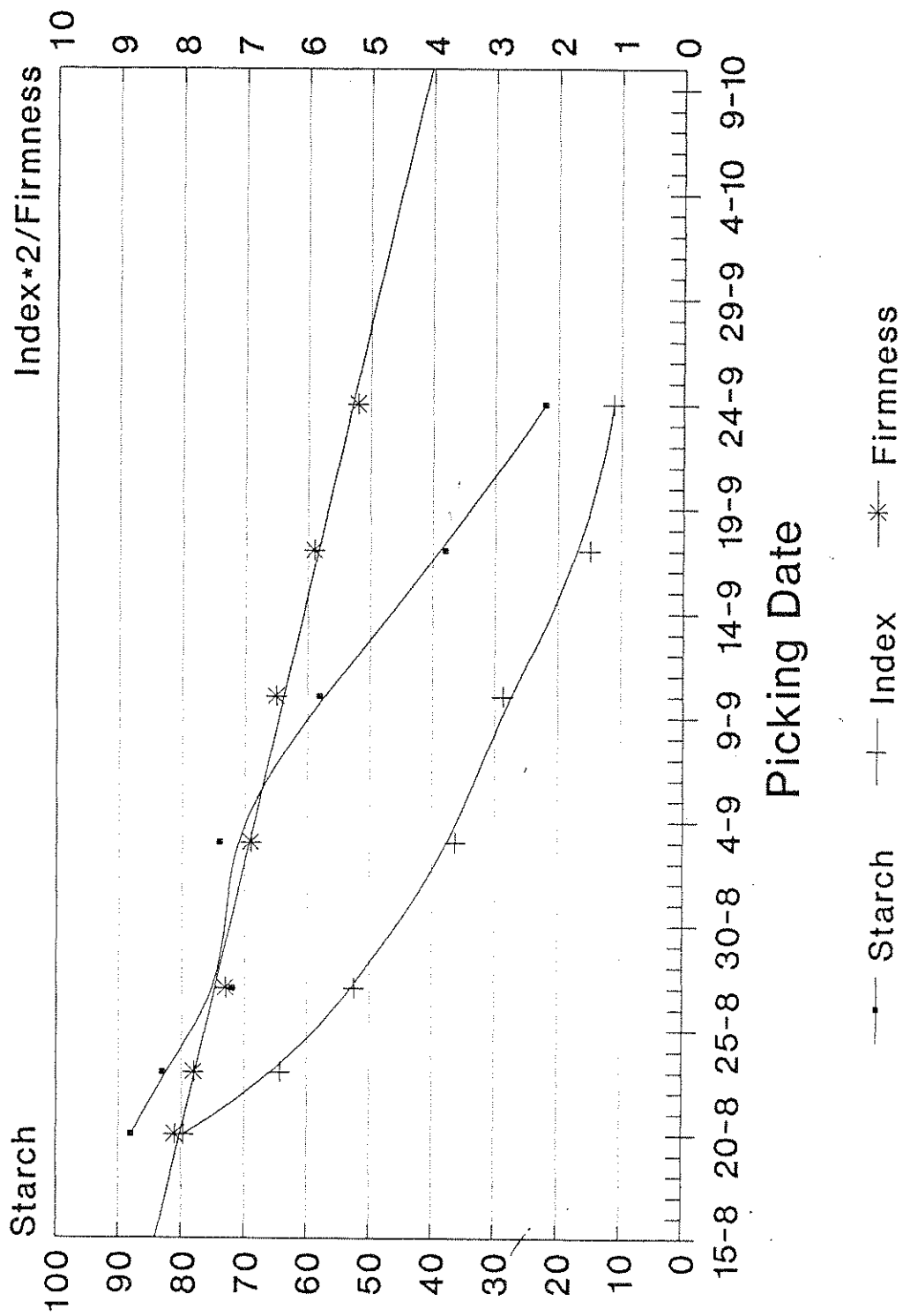
Harrel Amy's Cox M9 (WM7)



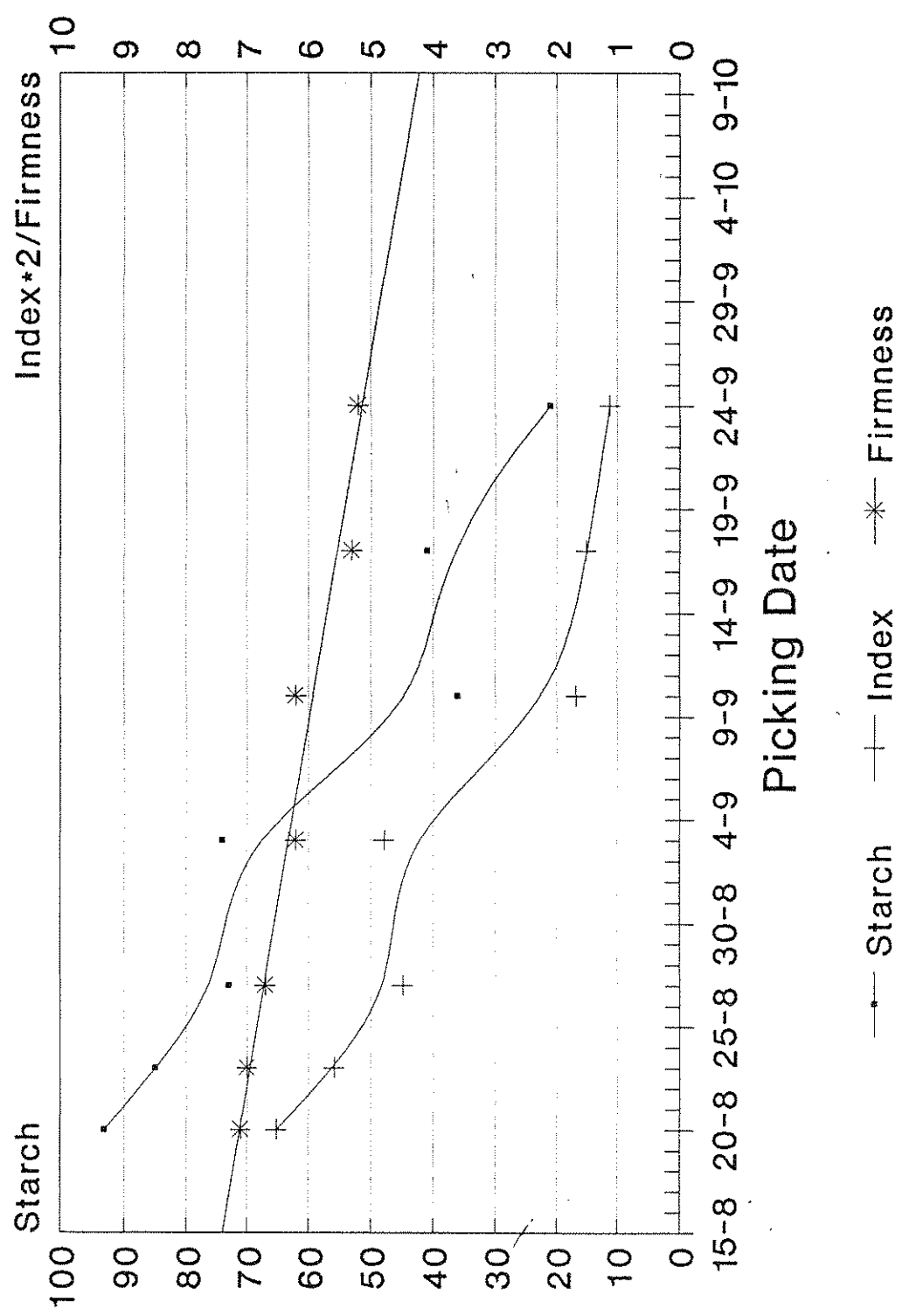
APPENDIX 2

**Graphs of fruit firmness, starch pattern
and maturity index with time for
each of the 5 Conference orchards**

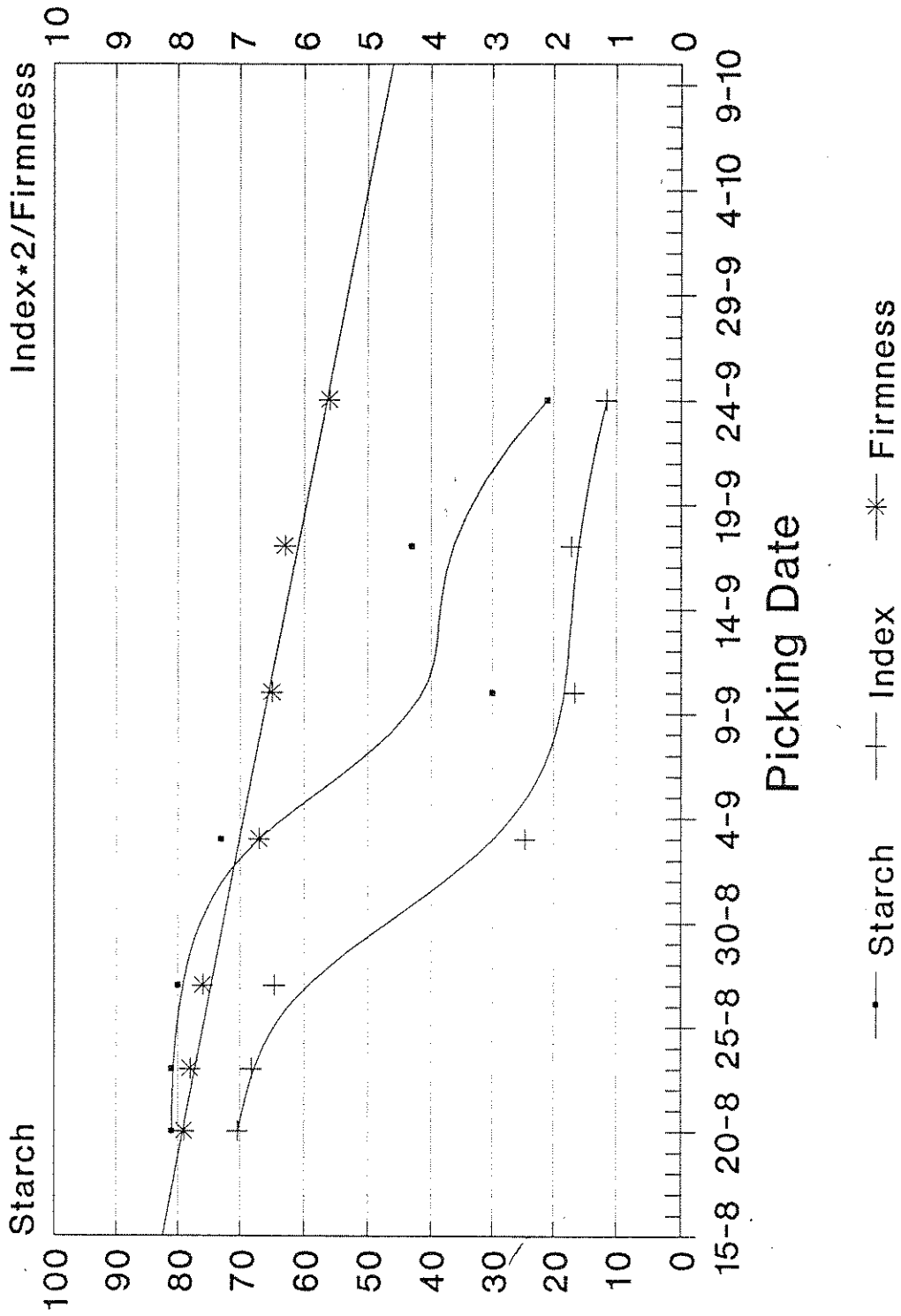
Sherenden Farm Stable Conf (PK1)



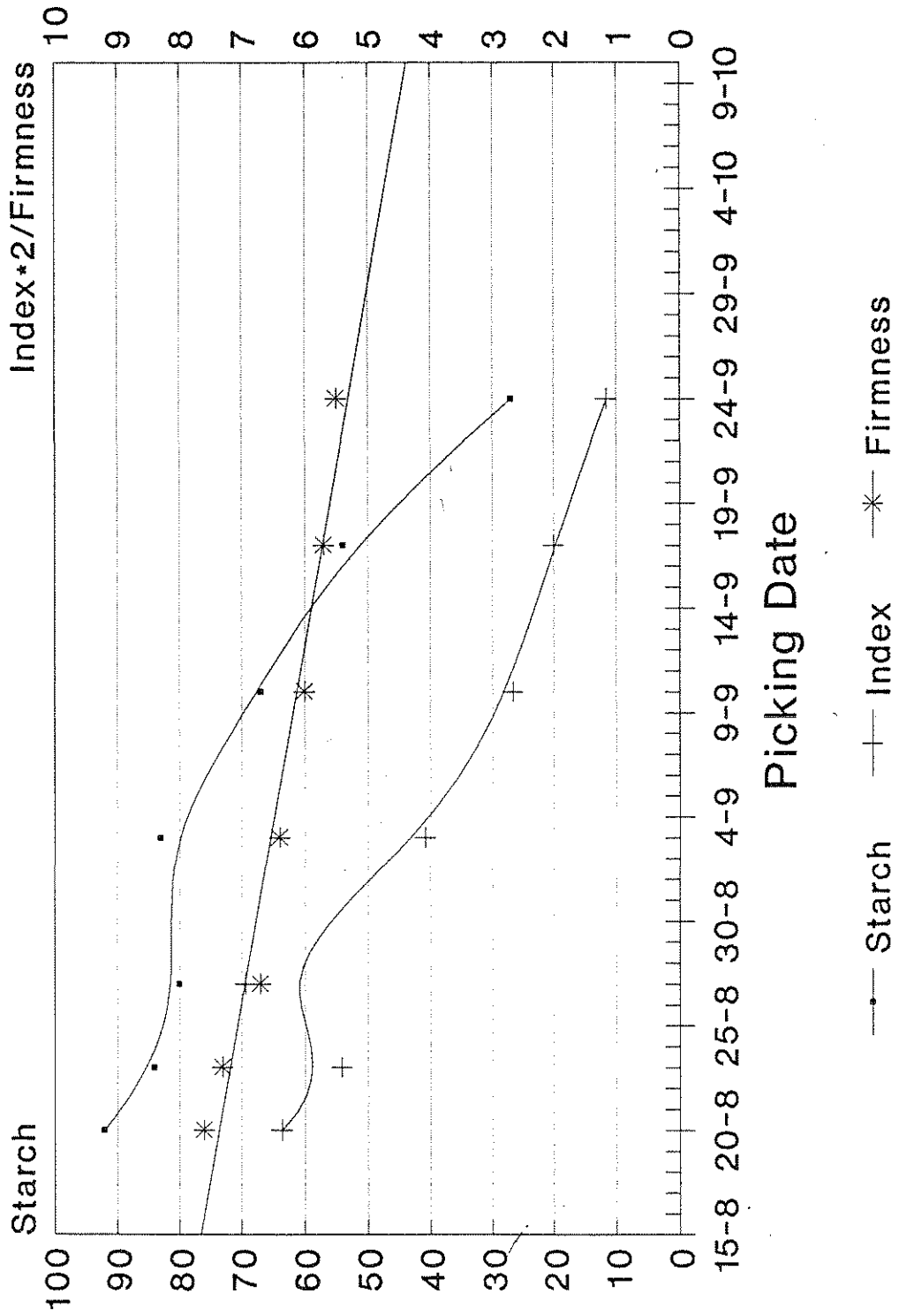
Mockbeggar Farm Greenhouse Conf (PK3)



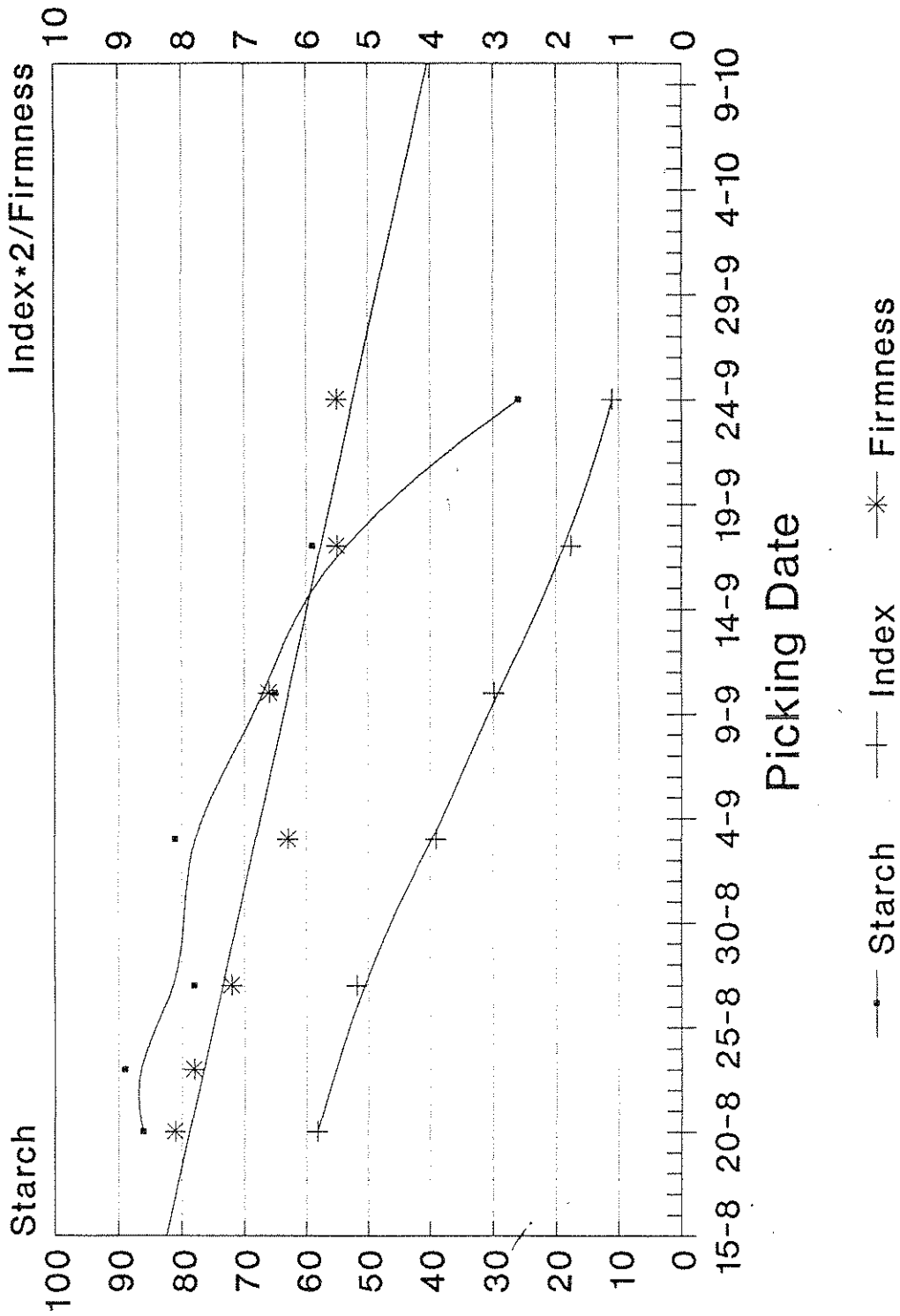
Foxbury Farm Block C Conf (PK4)



Highland Court Paramour Conf (PK6)



Feltons Farm Hs Conf (PEA2)



APPENDIX 3

**Average fruit firmness, sugar content, background
colour and internal condition of fruit after
20 weeks storage in 1.2%O₂ and after 10 days shelf life
for 10 Cox sites at four different harvest dates.**

Quality Fruit Group
Storage Results

Immediate ex-store 20/01/1998 C.A. Storage 1.2% O2 Inspection 1				
Site	Pick	Firmness	Sugar	Colour
Firmin Cobbler	1	6.7	13.6	1.4
	2	5.1	13.3	1.7
	3	5.5	14.8	1.8
	4	5.5	14.5	2.3
Firmin Maytums	1	6.5	14.3	1.7
	2	5.8	12.3	1.5
	3	5.2	12.5	1.8
	4	5.7	13	2.8
Clews Jubilee	1	6.7	14.4	1.2
	2	6.3	13.1	1.6
	3	5.9	13.9	1.7
	4	5.6	14.6	2.5
Wakley Amber	1	7	15.2	1
	2	7.1	17.5	1.9
	3	5.7	15.3	3
	4	6.3	16	2.7
Bray A19	1	6.5	16.7	1.6
	2	6.6	16.8	1.8
	3	5.8	16.6	2.6
	4	5.6	16.4	3.1
Chandler Potts	1	6.4	15.7	1.3
	2	6	16.1	1.8
	3	5.8	16.2	2.8
	4	5.2	15.4	2.9
Neuteboom Flint	1	7.3	15.9	1.6
	2	7.8	16.4	1.8
	3			
	4	6.6	17.1	2.6
Boxford Plains	1	6.7	15.1	1.6
	2	7	16.1	1.8
	3	6.5	17.1	2.7
	4	6	16.3	3.3
Feltons Horseshoe	1	7.1	16.3	1.6
	2	7	15.2	1.8
	3	6.2	16.4	2.3
	4	6.4	16.8	3
Ranworth New Lodge	1	6.7	14.5	1.7
	2	7.1	15.5	1.6
	3	5.9	15.7	2.4
	4	6.3	15.8	2.4

Quality Fruit Group
Storage Results

Immediate ex-store 20/01/98 C.A. Storage 1.2% O2 Inspection 1				
Site	Pick	Bitter	Senescence	Rot
Firmin Cobbler	1	0	0	0
	2	0	0	5
	3	0	0	0
	4	0	0	5
Firmin Maytums	1	0	0	5
	2	0	0	20
	3	0	0	0
	4	0	0	0
Clews Jubilee	1	0	0	0
	2	0	0	0
	3	0	0	5
	4	0	0	0
Wakley Amber	1	0	0	10
	2	0	0	0
	3	0	0	5
	4	0	0	20
Bray A19	1	0	0	0
	2	0	0	0
	3	0	0	0
	4	0	0	10
Chandler Potts	1	0	0	0
	2	0	0	10
	3	0	0	0
	4	0	0	5
Neuteboom Flint	1	0	0	0
	2	0	0	5
	3			
	4	0	0	0
Boxford Plains	1	0	0	0
	2	0	0	0
	3	0	0	0
	4	0	0	0
Felton Horseshoe	1	0	0	0
	2	0	0	0
	3	0	0	10
	4	0	0	0
Ranworth New Lodge	1	0	0	0
	2	0	0	0
	3	0	0	0
	4	0	0	0

Quality Fruit Group
Storage Results

Shelf life 10days at 18deg 31/01/98 C.A. Storage 1.2% O2				
Site	Pick	Texture	Taste	Aromatic
Firmin Cobbler	1	5	4	3
	2	5	4	3
	3	6	5	4
	4	7	5	6
Firmin Maytums	1	6	3	1
	2	6	3	1
	3	6	4	2
	4	7	4	2
Clews Jubilee	1	5	4	1
	2	5	4	1
	3	7	4	2
	4	7	5	2
Wakley Amber	1	5	3	1
	2	6	4	2
	3	7	4	2
	4	8	5	5
Bray A19	1	6	3	2
	2	7	4	3
	3	7	5	5
	4	8	5	6
Chandler Potts	1	5	3	2
	2	5	4	3
	3	7	5	4
	4	8	5	5
Neuteboom Flint	1	4	4	3
	2	4	4	3
	3			
	4	5	5	5
Boxford Plains	1	4	3	1
	2	4	4	2
	3	6	5	3
	4	7	5	5
Feltons Horseshoe	1	4	4	3
	2	4	4	3
	3	5	5	5
	4	6	5	7
Ranworth New Lodge	1	3	3	1
	2	4	4	2
	3	5	5	4
	4	6	5	6

Quality Fruit Group
Storage Results

Shelf Life 10 days at 18deg 31/01/ 98 C.A. Storage 1.2% O2 Inspection 1				
Site	Pick	Bitter	Senescence	Rot
Firmin Cobbler	1	0	0	10
	2	0	0	10
	3	0	0	10
	4	0	0	10
Firmin Maytums	1	0	0	10
	2	0	0	15
	3	0	0	5
	4	0	0	0
Clews Jubilee	1	0	0	10
	2	0	0	0
	3	0	0	20
	4	0	0	0
Wakley Amber	1	0	0	15
	2	0	0	20
	3	0	15	10
	4	0	0	10
Bray A19	1	0	0	10
	2	0	0	0
	3	0	0	10
	4	0	0	5
Chandler Potts	1	0	0	10
	2	0	0	25
	3	0	0	20
	4	0	0	5
Neuteboom Flint	1	0	0	20
	2	0	0	15
	3			
	4	0	0	10
Boxford Plains	1	0	0	0
	2	0	0	5
	3	0	0	0
	4	0	0	0
Feltons Horseshoe	1	0	0	0
	2	0	0	0
	3	0	0	5
	4	0	0	0
Ranworth New Lodge	1	0	0	5
	2	0	0	0
	3	0	0	10
	4	0	0	0

APPENDIX 4

**Average fruit firmness, sugar content,
background colour and internal condition
of fruit after 23 weeks in 1.2%O₂
and 10 days shelf life for 10 Cox sites at four
different harvest dates.**

Quality Fruit Group
Storage Results

Immediate ex-store 13/02/98 C.A. Storage 1.2% O2 Inspection 2				
Site	Pick	Firmness	Sugar	Colour
Firmin Cobbler	1	6.3	13.6	2
	2	5.2	13.4	1.9
	3	5	14.3	2.3
	4	4.9	14.2	2.2
Firmin Maytums	1	4.7	13.6	1.9
	2	4.6	13.2	2.1
	3	4.8	13.6	2
	4	5.2	14.3	2
Clews Jubilee	1	5.6	14	1.9
	2	5.3	13.9	2
	3	6.1	13.1	2.1
	4	5.4	15	2.3
Wakley Amber	1	6.6	15.3	1.9
	2	6.6	16.7	2.2
	3	5.8	15.6	2
	4	6.2	15.8	2.6
Bray A19	1	6.1	16.4	1.8
	2	5.9	16.2	2
	3	5.6	16.4	2.3
	4	5.3	16.6	2.2
Chandler Potts	1	5.7	16.2	2
	2	6.3	15.8	2.3
	3	5.4	16.1	2
	4	4.9	15.7	2
Neuteboom Flint	1	7.1	16.1	1.8
	2	6.9	17.3	1.8
	3	6.1	18.4	2
	4	6.2	17.5	2.4
Boxford Plains	1	6.3	15.5	1.9
	2	6.3	16.6	1.9
	3	5.4	17.4	2
	4	5.9	17.4	2.3
Feltons Horseshoe	1	6.9	16.5	1.8
	2	6.7	16.4	2.1
	3	5.4	16.1	2.2
	4	6	17.5	2.9
Ranworth New Lo	1	6.6	16	1.7
	2	7.1	15.2	2.2
	3	5.5	15.8	2
	4	6	16	2.2

Quality Fruit Group
Storage Results

Immediate ex-store 13/02/98 C.A. Storage 1.2% O2 Inspection 2				
Site	Pick	Bitter	Senescence	Rot
Firmin Cobbler	1	0	0	10
	2	0	0	30
	3	0	0	0
	4	0	0	10
Firmin Maytums	1	0	0	5
	2	0	0	5
	3	0	0	5
	4	0	0	5
Clews Jubilee	1	0	0	5
	2	0	0	0
	3	0	0	0
	4	0	0	0
Wakley Amber	1	0	0	0
	2	0	0	0
	3	0	5	0
	4	0	0	0
Bray A19	1	0	0	0
	2	0	0	0
	3	0	0	0
	4	0	0	0
Chandler Potts	1	0	0	10
	2	0	0	5
	3	0	0	5
	4	0	0	0
Neuteboom Flint	1	0	5	10
	2	5	0	15
	3	0	0	5
	4	0	0	0
Boxford Plains	1	0	0	0
	2	0	0	0
	3	0	5	0
	4	0	0	5
Felton Horseshoe	1	0	0	0
	2	0	0	0
	3	0	0	0
	4	0	0	0
Ranworth New Lodge	1	0	0	5
	2	0	0	10
	3	0	0	5
	4	0	0	5

Quality Fruit Group
Storage Results

Shelf Life 10 days at 18deg 23/02/ 98 C.A. Storage 1.2% O2 Inspection2				
Site	Pick	Bitter	Senescence	Rot
Firmin Cobbler	1	5	0	15
	2	0	0	5
	3	20	0	0
	4	0	0	5
Firmin Maytums	1	0	0	20
	2	0	0	20
	3	0	0	20
	4	0	0	0
Clews Jubilee	1	0	0	5
	2	0	0	40
	3	0	0	15
	4	0	0	35
Wakley Amber	1	0	0	20
	2	0	0	40
	3	0	15	20
	4	10	20	5
Bray A19	1			
	2	0	0	0
	3	5	0	0
	4	0	0	10
Chandler Potts	1	0	0	30
	2	0	0	20
	3	0	0	70
	4	0	0	20
Neuteboom Flint	1			
	2	0	0	35
	3	0	0	30
	4	5	0	20
Boxford Plains	1			
	2	0	0	0
	3	10	0	5
	4	0	0	5
Feltons Horseshoe	1			
	2	0	0	5
	3	10	0	0
	4	0	0	20
Ranworth New Lodge	1			
	2	0	0	40
	3	0	0	10
	4	0	0	10