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REPORT TO

THE NEW ZEALAND BUTTERCUP SQUASH COUNCIL

1990-91 RESEARCH AND DEVELOPMENT PROGRAMME

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PENETROMETER REPORT EXTRACT

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INTRODUCTION

In the Spring of 1990 a contract was negotiated by the New Zealand Buttercup Squash Council for a programme of research to be undertaken by MAF and DSIR during the 1990 / 91 season. The programme was designed to achieve crop quality improvements by undertaking two parallel studies with collaborative research inputs by MAF and DSIR.

Harvest maturity in buttercup squash has been an area of concern for the New Zealand industry since the very early days of export to Japan. The initial guidelines for harvest maturity were quite subjective, based on visual observation of the exterior changes in skin and stalk colour of the squash and the internal colour of the flesh, and the taste and texture preferences of a few people. The correlation was made for the Pukekohe area, the only significant production area at the time, and was acknowledged to be a guideline for the industry with considerable limitations, rather than a fully established maturity test. Despite the limitations the maturity guidelines have served a useful purpose for the industry.

The spread of buttercup squash production for export into new areas and the need to remain competitive by improving squash quality for the consumer has resulted in the need to review the maturity standard. However, the introduction of a fully researched and tested minimum maturity standard would require considerable research input and an industry inspection/assurance system to ensure its implementation. The maturity standard should relate the physiological stage of development of the squash at harvest with the quality criteria important to the final consumer. Seasonal and district differences in maturation, and in quality, must be understood, along with the variation that might be expected within an individual field. Changes to quality criteria that occur after harvest, as well as the storage, transport and marketing conditions must be understood. Most important however, is the need to fully appreciate the quality criteria that are important to the consumer. This will enable the harvest maturity standard to be set at a level to ensure that the squash is acceptable to the consumer.

In addition to the need for objective measures of maturity and quality there is a need to define optimum crop handling practices to minimize the incidence of storage rots At present there is considerable variability throughout the squash industry regarding the ways in which fruit are treated between harvest and shipping. The key elements in an optimum handling regime have yet to be objectively identified.

The study objectives were:

1. To investigate the usefulness of the penetrometer as a guide to crop maturity.

2. To investigate harvest / handling / storage practices which reduce rots during storage.

3. To investigate the changes in quality characteristics during simulated shipping regimes.

The report is presented in three sections:

A. Details of the penetrometer study

B. Harvest, handling storage practices and their influence on rot incidence

C. Changes in quality during storage.

SUMMARY OF RESULTS

A. Penetrometer Study

- Average penetrometer readings of 8.5 indicated an acceptable level of fruit maturity in the regions sampled. (This is confirmation of 1989 / 90 trial work.)

- There was a strong correlation between penetrometer readings and other indicators of fruit maturity:
  * flesh colour
  * stem corking
  * dry matter (1989 / 90 trials)

- There were no significant differences between cultivars tested.

- The rate of fruit development was greater in the North Island compared to Canterbury sites sampled.

  The survey showed a difference of 8 - 10 days from flowering to harvest between Canterbury and the North Island.

- Stem corking is a useful indicator of fruit maturity, but the amount of corking required is greater than 65% of the stem. This is higher than the previous industry practice.

  Observations in the study indicated some significant site variations in degree of stem corking, especially on peat type soils.

- External skin colour did not show any correlation with other maturity indices used.

B. Post-harvest handling practices

- Fruits harvested as soon as they had reached commercial maturity (penetrometer of 8.2-8.5) developed many fewer storage rots than did fruit harvested 4 weeks later.

- Fruits stored at 12-15 C developed many fewer rots than did fruit stored at 30-33 C.

- Incidence of storage rots was the same for fruit given either 2, or 6 days conditioning at ambient temperatures before being placed in controlled temperature storage. The effect of a 9-day conditioning period was different for the two harvests and for the two storage temeperatures.

- There was no effect of washing and brushing, either before, or after, conditioning, on the incidence of storage rots.

C. Post-harvest changes in quality

- There were significant changes in several quality characteristics during storage.

- Maturity was advanced by storage at 30 C compared with storage at 12-15 C.

- Among the more noticeable changes in fruit quality were increased soluble solids and darkened (more orange) flesh colour for fruit stored at 30-33 C.

RECOMMENDATIONS - SPECIFIC

- Use of the penetrometer can provide an objective assessment of fruit maturity in the field.
- A set sampling procedure is required:
    * minimum 25 fruit per paddock
    * average penetrometer reading to be 8.5
    * 5 measurements per fruit
    * random selection of fruit (at diagonal across block)
    * 2 samples for assessment commencing 35-40 days after full flowering

      OR

      when corking is apparent on the stems of most fruit

- Penetrometer readings should be recorded and used as a record to show that field maturity was reached prior to harvest. This system could be adopted by the Squash Council as part of the Quality Assurance programme.

- **NOTE:** The reliability of penetrometers as a post harvest (ie pack measurement of fruit maturity has not been established in this study.

- Optimum practices to reduce storage rots to a minimum of 2-3% after 3-4 weeks storage are:
    * harvest fruit as soon as it reaches commercial maturity i.e. a penetrometer reading of 8.5.
    * condition the fruit for 2 days at ambient temperature before placing in controlled temperature storage.
    * store/ship fruit at 12-15 C.

- Quantifiable, objective household consumer maturity standards need to be determined for the Japanese market. There were quite significant changes during storage in attributes often associated with (NZ) perceptions of maturity but they may not be the only ones of interest to the consumer.

RECOMMENDATIONS - GENERAL

- Improved mechanisms need to be established for the dissemination of R&D results and the implementation by the industry of specific recommendations resulting from the R&D programme.

- A list of R&D projects should be developed by wide industry consultation and then priorities established by the Squash Council and their R&D manager. Possible projects, suggested by the R&D team, are listed below:
    - determine Japanese consumer preferences
    - determine cause(s) of "pin rot" in Canterbury
    - determine the rot-reducing effects of short duration, high temperature pre-storage conditioning
    - fine tuning of the adoption of the penetrometer assessment of harvest maturity
    - effect of irrigation on yield and storage quality
    - evaluation of new DSIR Crop Research cultivars for rot

SECTION A:

THE PENETROMETER

AS A QUIDE

TO CROP MATURITY

Guy Wishart - MAF Technology, Pukekohe

Ian Brice - MAF Technology, Gisborne

Robin Brooks - MAF Technology, Lincoln

SECTION A: Penetrometer Study

1. **Objectives**

- To verify trial results from 1989 / 90 season in different regions.
- To develop a field testing method for maturity assessment
- To establish any regional differences in fruit development.

2. **Experimental Methods**

Plot Number and Region

* Twenty six blocks were selected from 3 major growing regions.

They were;		
	Auckland	10
	Gisborne	6
	Canterbury	10

Sample Size and Timing

* A random sample of 30 - 50 fruit was taken from each paddock on three separate occasions. Several samples were taken sequentially across the paddock to aid sample size estimates.
* The sample times were approximately 27, 39 and 51 days after fruit set.
    * The third and final sampling was at harvest.

Fruit Measurements / Data Collection

* The following details regarding the fruit were recorded:
    - variety
    - stem corking (graded 0-10: 0=no corking; 10=fully corked)
    - skin colour (only on 4 samples)
    - penetrometer measurements (6 per fruit)
    - flesh colour measurements (4 - 6 readings - in Auckland and Canterbury only)
* All 3 penetrometers used in the study were tested for equality; all were found equal. An arbitrary kilogram scale was used. The tips used were the same size as in the previous year's study.
* The colour measurements were done by use of a chromometer (Minolta CR 200). Machines were calibrated to each other at the beginning of

the season. The colour measurement were recorded in L.A.B. units.

* No information concerning fertilisers, pest and disease, or any other cultural information was collected as the penetrometer needed to stand alone as a maturity indicator, independent of any variables present.

3. Results and Discussion

3.1. Stem Corking as an indicator of Crop Maturity

(Refer to Fig 1, 2 and 3, and Appendix 1)

Stem corking appeared to be a useful indicator of fruit maturity on most soils. Peat soils in particular, appeared to show different levels of corking to other soil types.

At sample date 1, the average site corking over all properties was 2, by sample date 2 it was 4.5 and by sample date 3 it was 8 (Fig 1). This indicated that previously recommended stem corking scores of 5 at harvest were a little low.

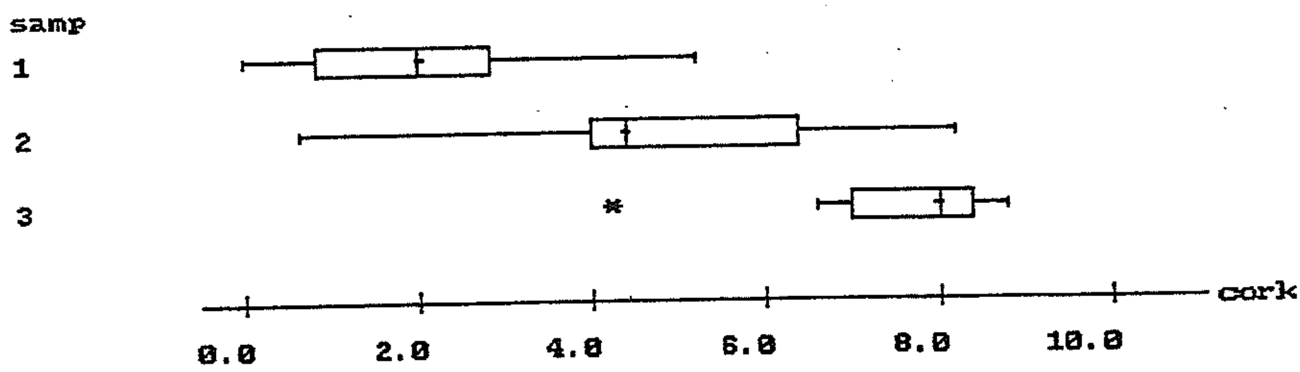
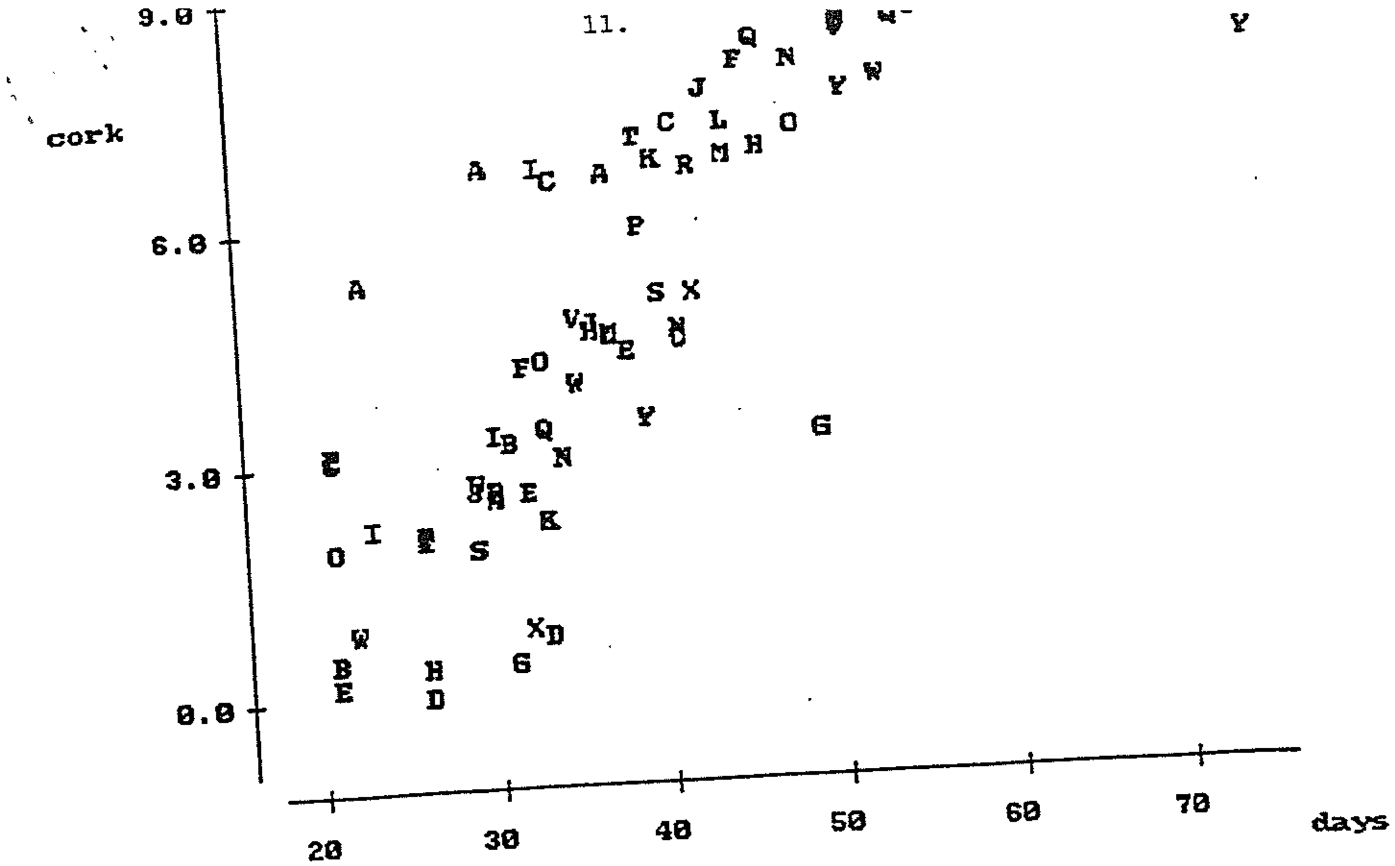


Fig 1 Site average stem corking score at the 3 sampling times.
NB The crossbar represents the median, while 50% of the sites had a mean corking within the box. The remainder are represented by the whiskers either side of the box.

Stem corking levels at harvest on peat soils tended to be between 3 and 5 (Fig 2).

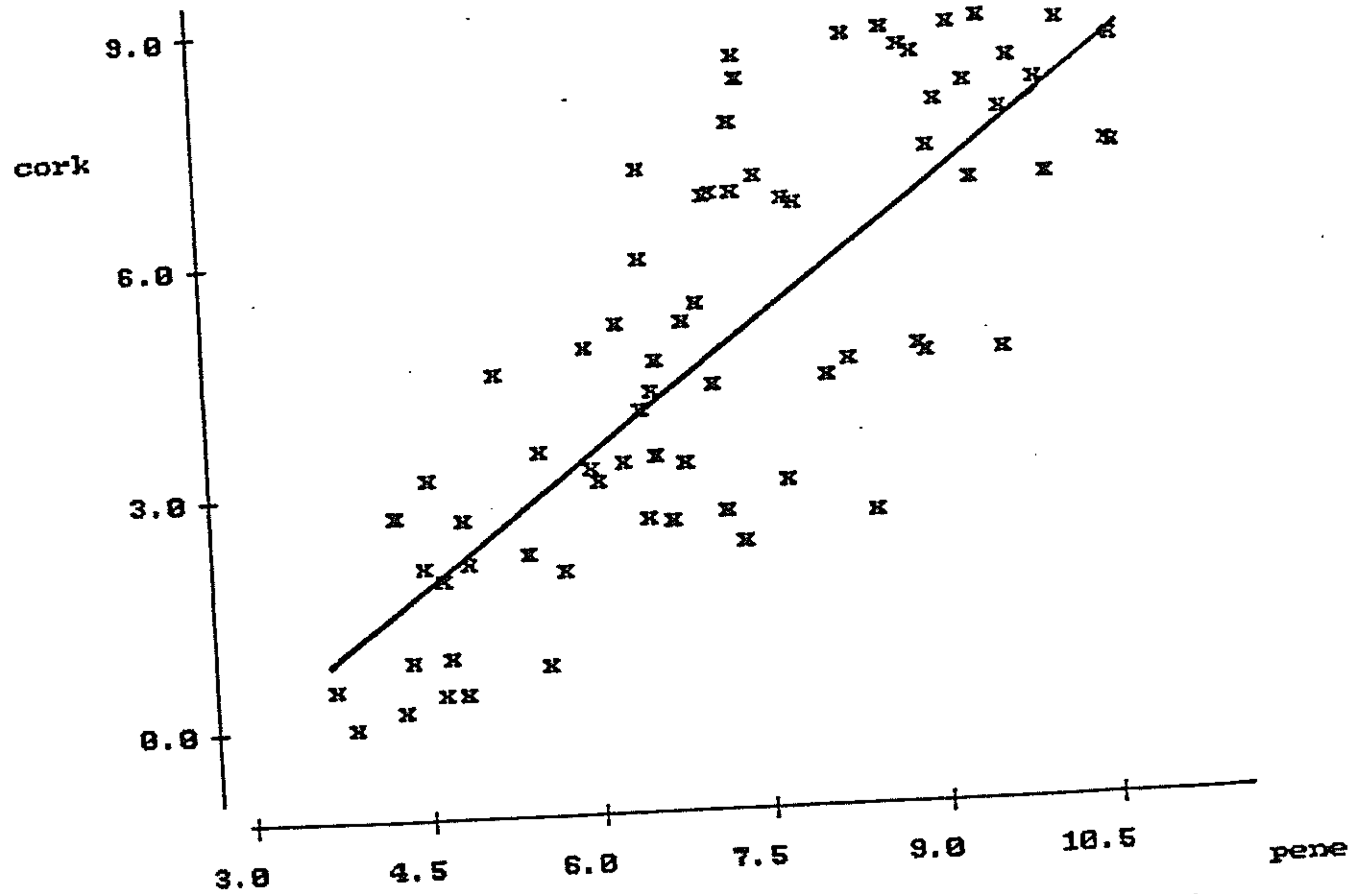
A corking level of 6.4 gives an average reading of 40 - 45 days post flowering (Fig 2).

At a penetrometer level of 8.5, the corking level is around 6.4 (Fig 3).



N* = 4

Fig 2 Site average stem corking scores versus days from flowering
NB The graph identifies the site means of all the blocks sampled, at the 3 sampling dates.



N* = 4

Fig 3 Site average corking scores versus site average penetrometer values
NB At a penetrometer reading of 8.5 the stem corking score is 6.4. The corking number is estimated by the equation -3.42 + (1.15 x P), where P is the site average penetrometer reading.

3.2. Skin Colour as an Indicator of Maturity

(Refer to Fig 4a and b)

Four readings of skin colour were taken during the season. These readings were plotted against penetrometer and flesh colour readings.

Fig 4a and 4b represent one of these readings.

There was no correlation seen between skin colour and penetrometer/flesh colour readings for all four samples. It was also observed that densely canopy covered crops tended to be a lighter green than lightly covered crops.

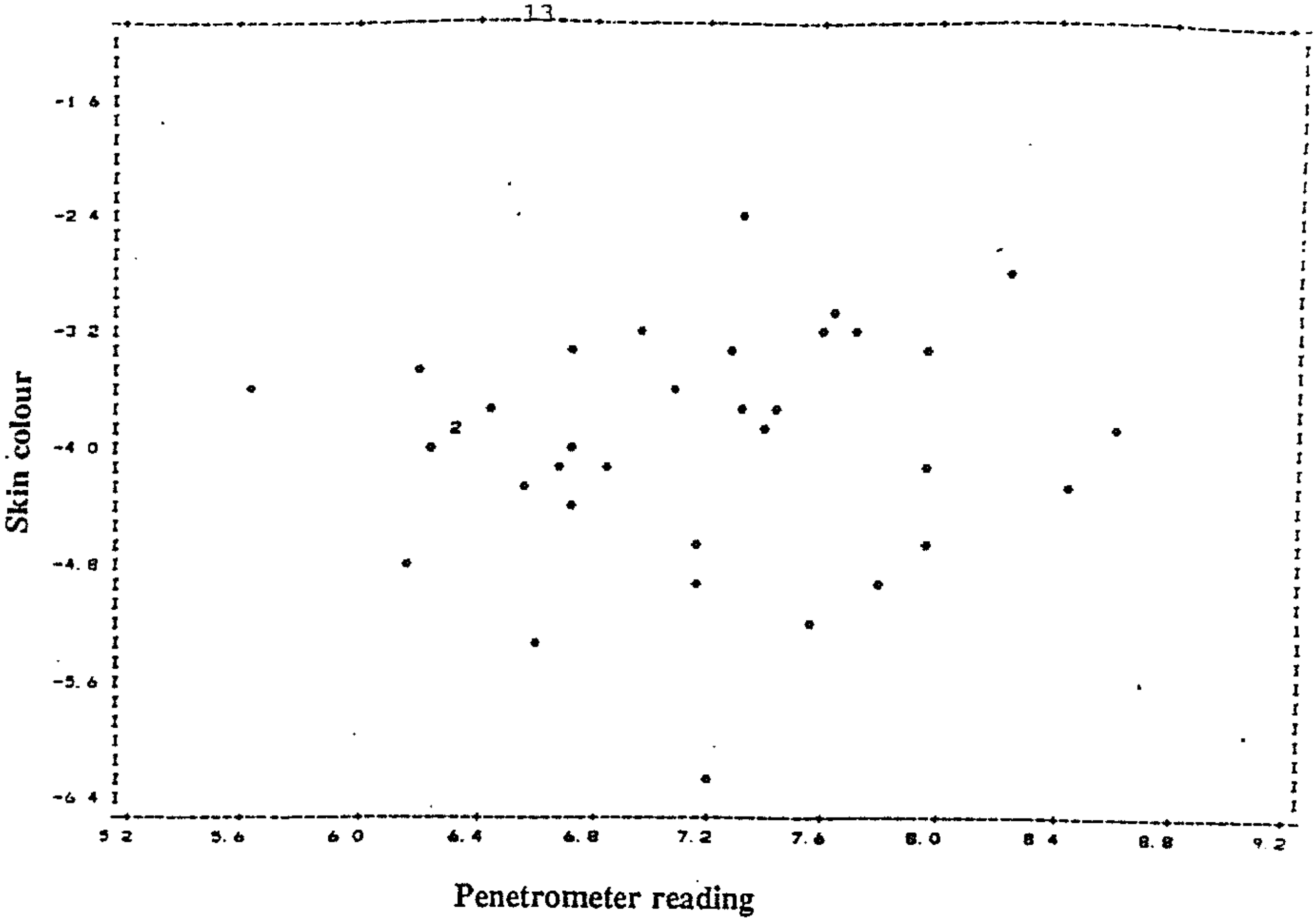


Fig 4a Skin colour versus penetrometer
NB This was for Grower A, sample 2.

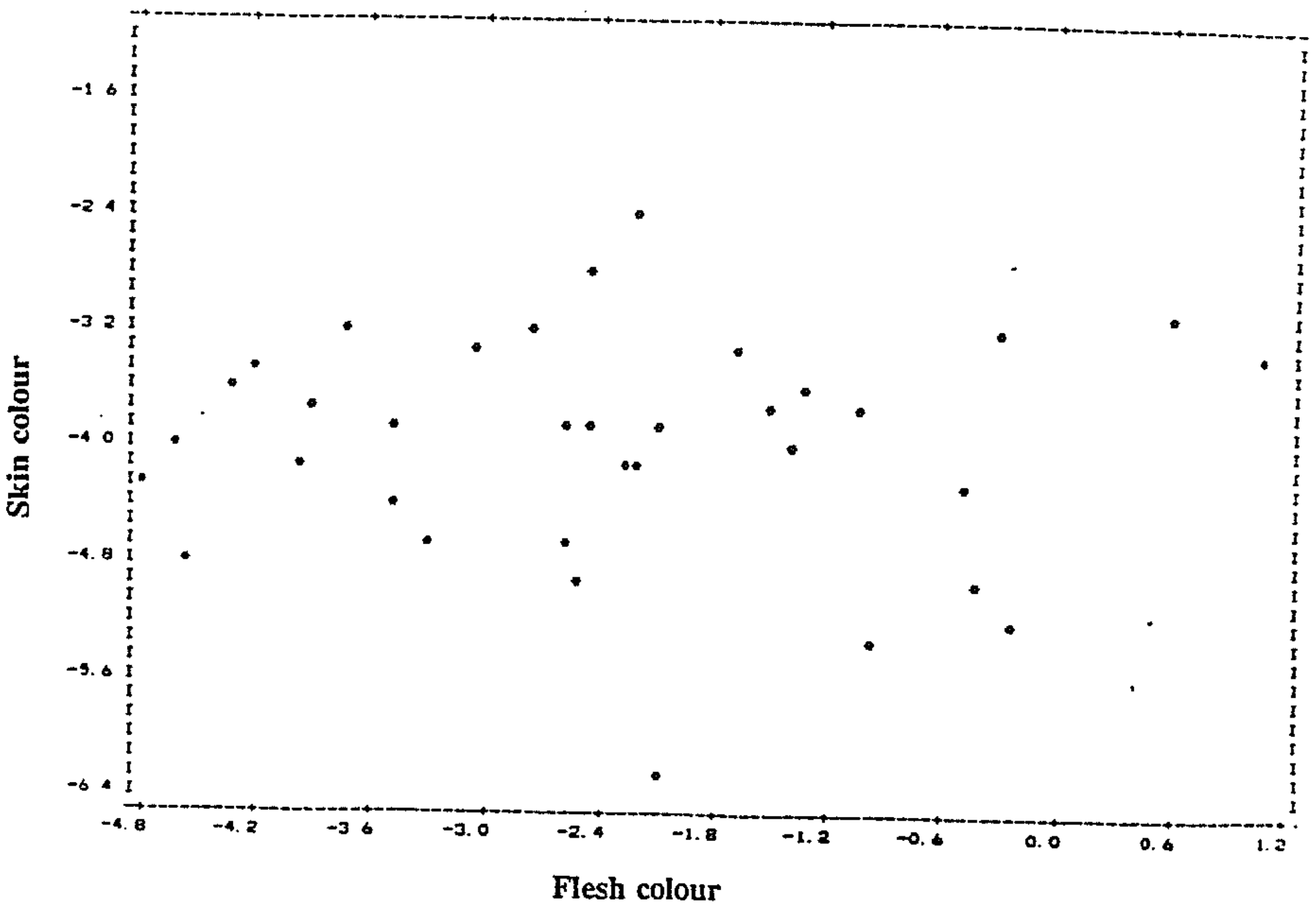


Fig 4b Skin colour versus flesh colour
NB This was for Grower A, sample 2

3.3. Penetrometer Readings as an Indicator of Maturity

(Refer to Fig 5 - 8 plus 11, and Appendix 2 - 5)

Penetrometer readings were taken at 3 sampling times per crop (Fig 5). Overall, the site average penetrometer values were:

Sample date A	4.7
Sample date B	6.8
Sample date C	8.8

(NB : also see Appendix 5 for individual block differences)

It must be stressed that Gisborne tended to harvest their fruit at a higher level of maturity than Auckland and Canterbury. Gisborne was using a growing degree day to assess optimum maturity.

There was a strong correlation between site average penetrometer readings and flesh colour / stem corking (Fig 3 and 11).

This relationship had a regional difference with Gisborne's fruit generally hardening first, followed by Auckland and Canterbury (Fig 7). It must also be noted that fruit from South Auckland were late season samples in general, with earlier season samples from Auckland likely to have been comparable to Gisborne in this regard.

Average days to the penetrometer level of 8.5 for the three districts are as follows (Fig 7):

Gisborne	36 days from flowering
South Auckland	49 days from flowering
Canterbury	56 days from flowering

The individual property readings are recorded on Fig 8.

An average fruit penetrometer reading of 8.5 was regarded as being the minimum acceptable field maturity level. This level took into account the spread of maturity within a paddock at harvest.

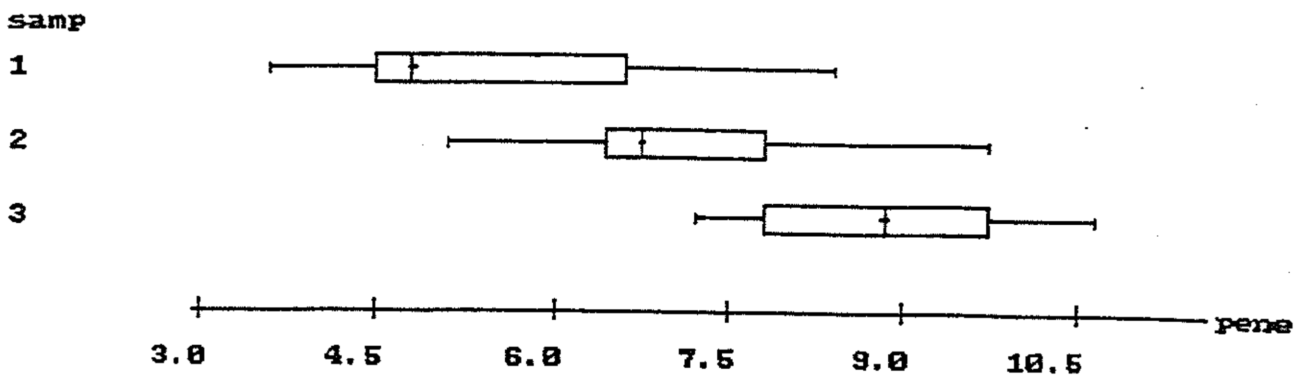


Fig 5 Site average penetrometer values for all sites at the 3 sample dates
NB The crossbars represent the median; 50% of the sites had a mean penetrometer value within the box. The remaining 50% are represented by the whiskers outside the box.

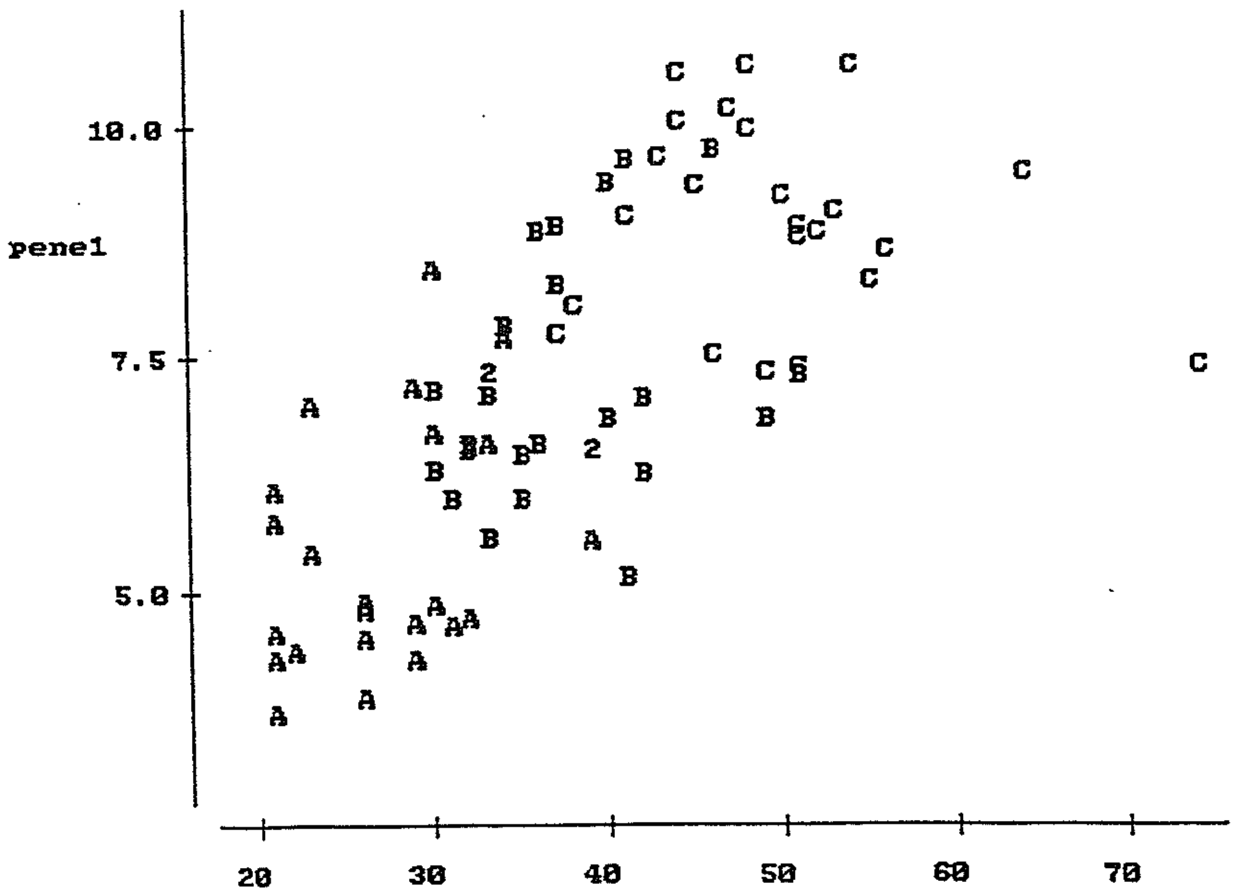


Fig 6 Site average penetrometer values versus days from flowering for each sampling time, A B and C.
NB 50% of growers harvested their crops between 44 and 53 days after flowering.

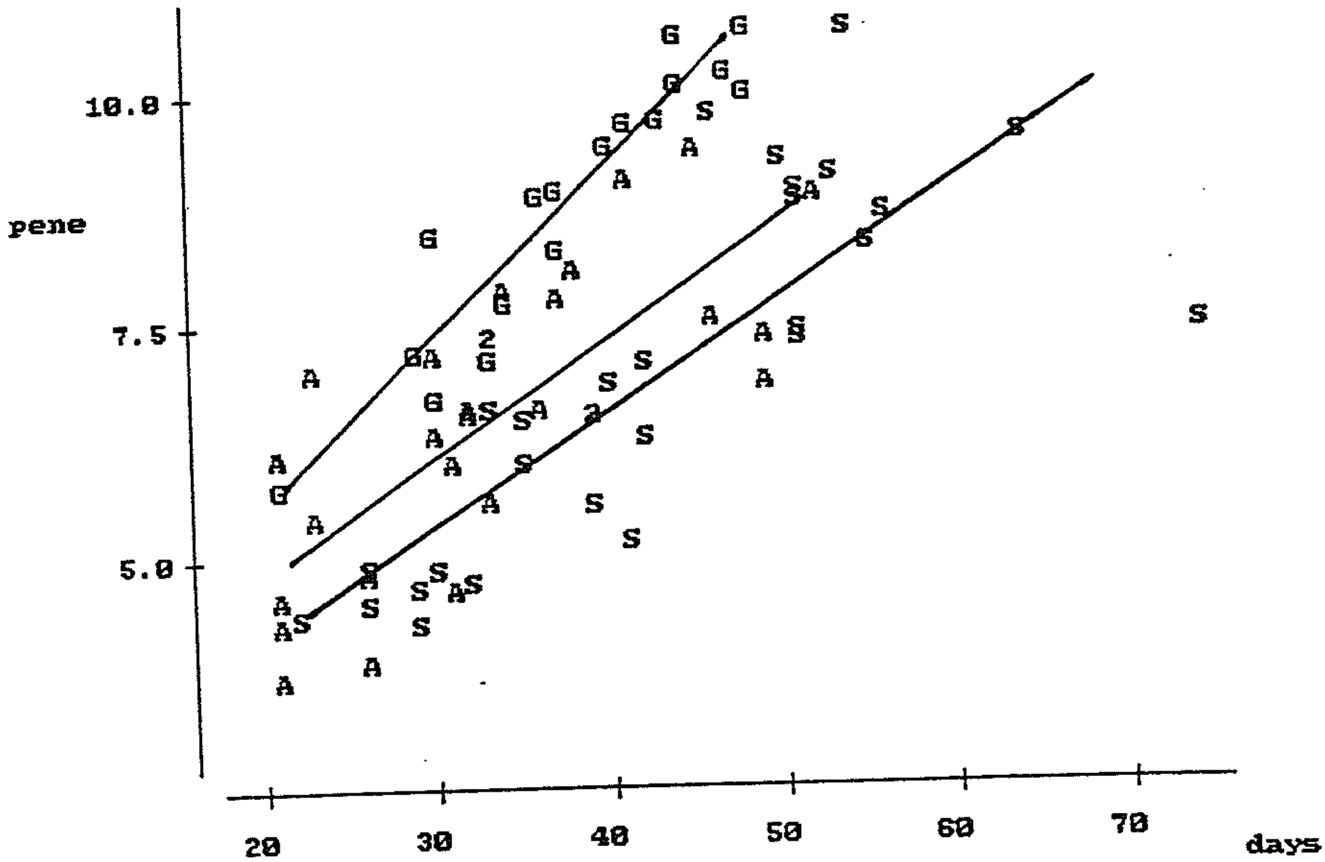


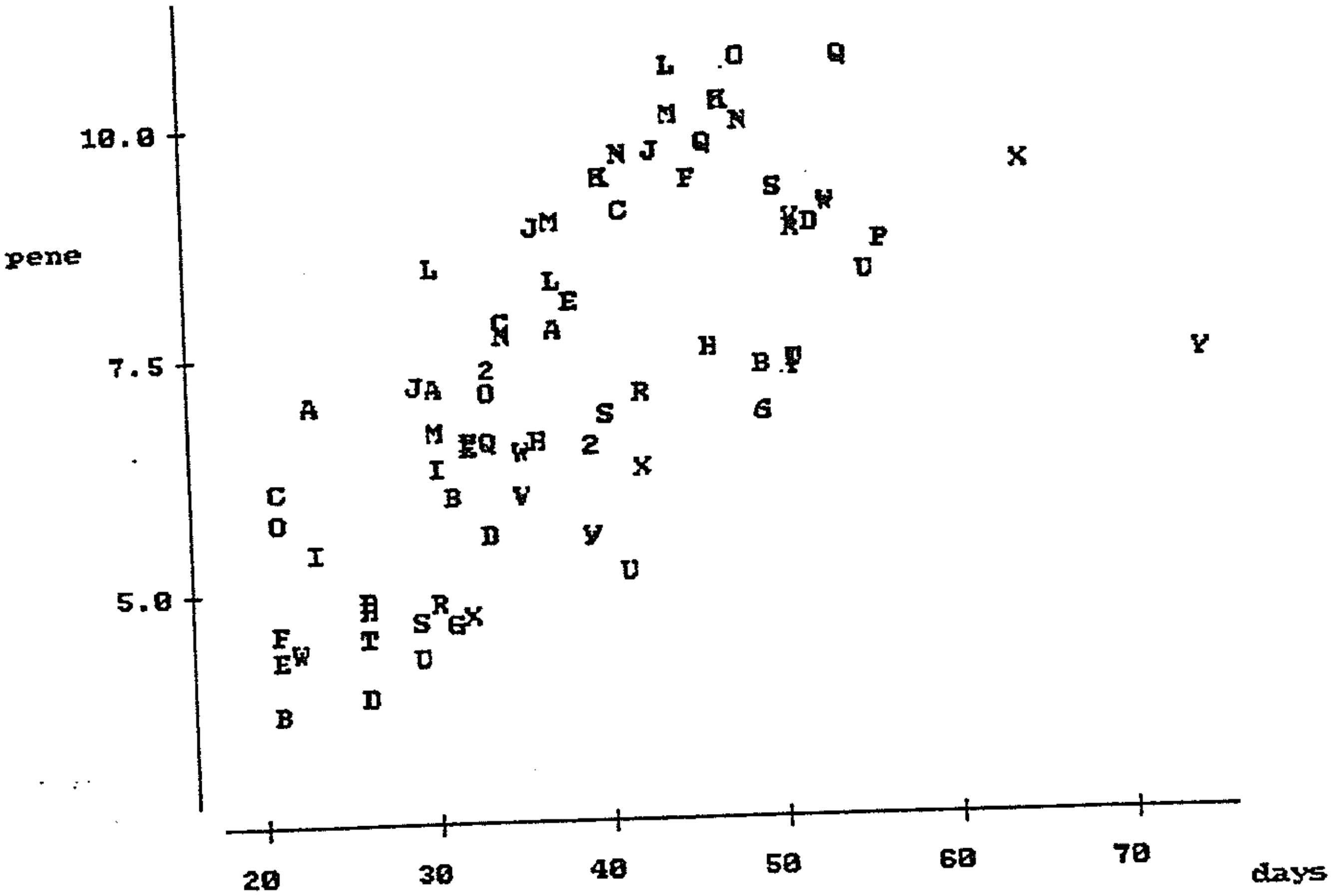
Fig 7 Site average penetrometer values versus days from flowering. (Regions: G = Gisborne, A = Auckland, S = South Island)

NB The lines drawn estimate the best fit as predicted by computer. The mathematical relationships for each region are as follows:

Auckland: Penetrometer reading = 2.38 + (0.124 x days)

Gisborne: Penetrometer reading = 1.84 + (0.183 x days)

South Island: Penetrometer reading = 1.76 + (0.121 x days)



N* = 2

Fig 8 Site average penetrometer values versus days from flowering (Grower A - Y at each harvest date)

4. Flesh Colour as an Indicator of Field Maturity
(Refer to Fig 9 - 11 plus Appendix 5)

General Comment

All flesh colour readings were taken using LAB measurements. Only the "A" value was used for analysis as it examines the shift from green to red (-ve to +ve). Values for Gisborne are not present.

The colour shift from green to red was present in all site averages, with increasing fruit age (Fig 9 and 10).

At the time the crops were harvested 50% of samples showed a mean site flesh colour value of between about 2 and 4.

There is a strong relationship between site average flesh colour and site average penetrometer values (Fig 11).

At the site average penetrometer value of 8.5, a corresponding site average flesh colour is close 4 (Fig 11).

Flesh colour is a useful indicator of field maturity. However, the minute differences measurable by machines is not likely to be seen by growers or agreed upon between growers.

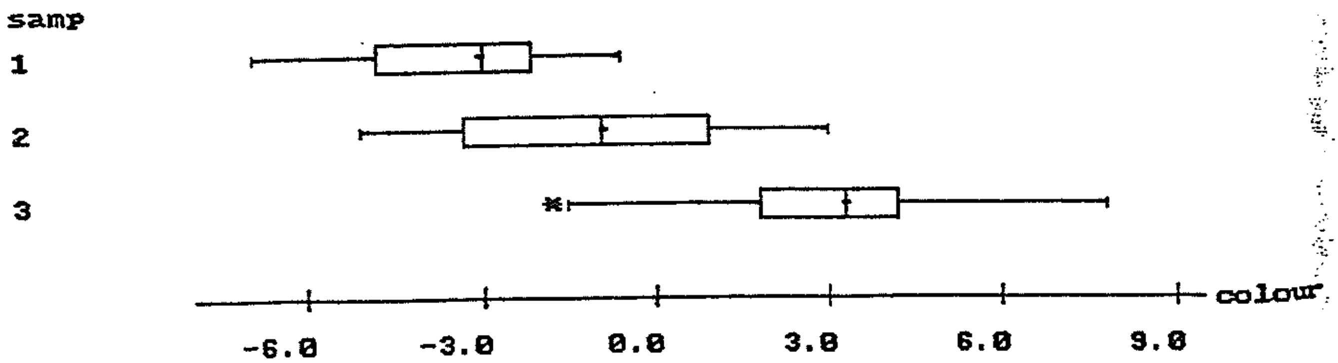


Fig 9 Site average colour values for all sites except Gisborne, at the 3 sampling times

NB The crossbar represents the median; 50% of the sites had a mean colour value within the box. The remaining 50% are represented by the whiskers outside the box.
All colour readings use LAB units, only "A" is graphed.

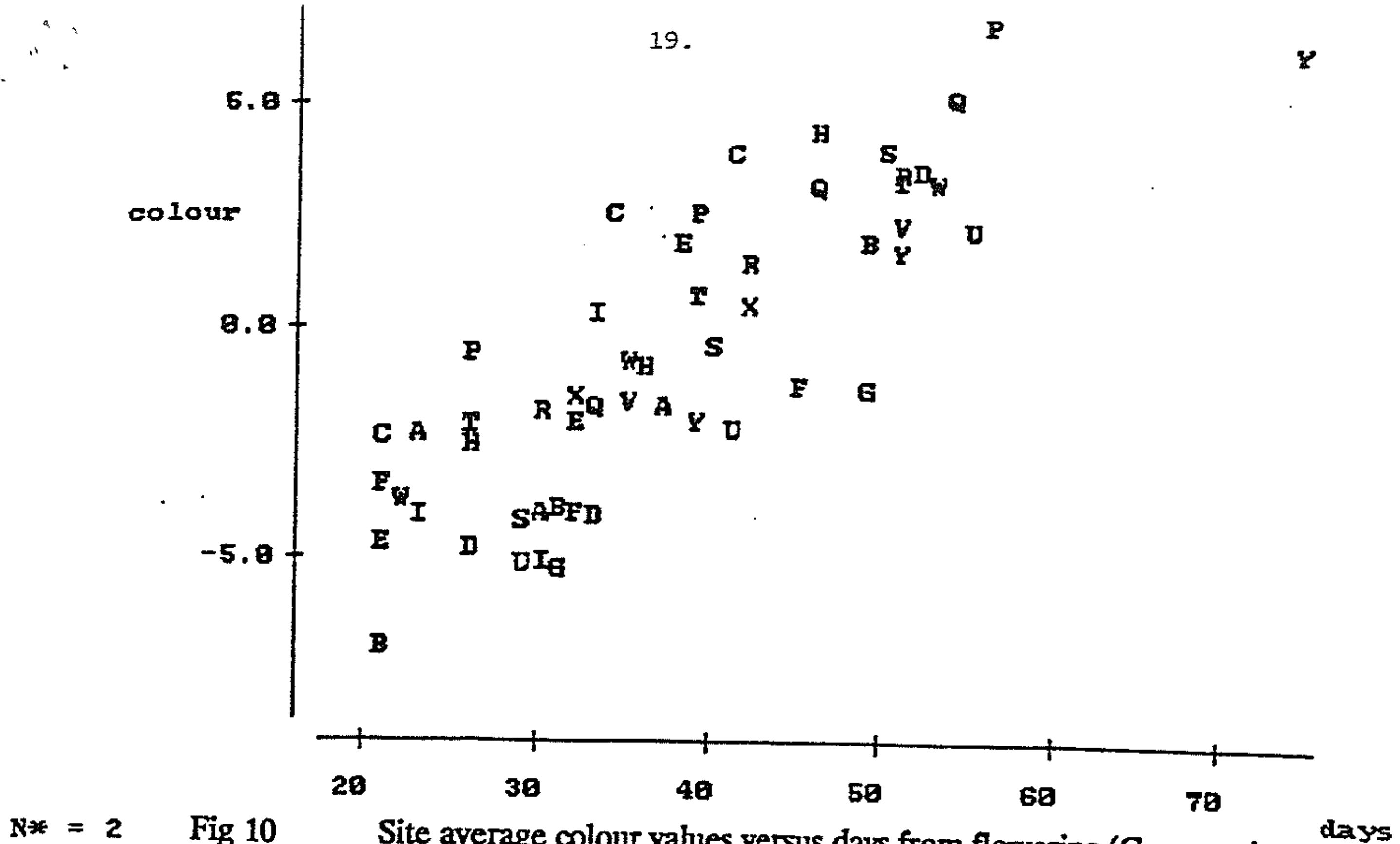


Fig 10 Site average colour values versus days from flowering (Growers A - Y at the three sampling times.

NB Gisborne is not included in this data.

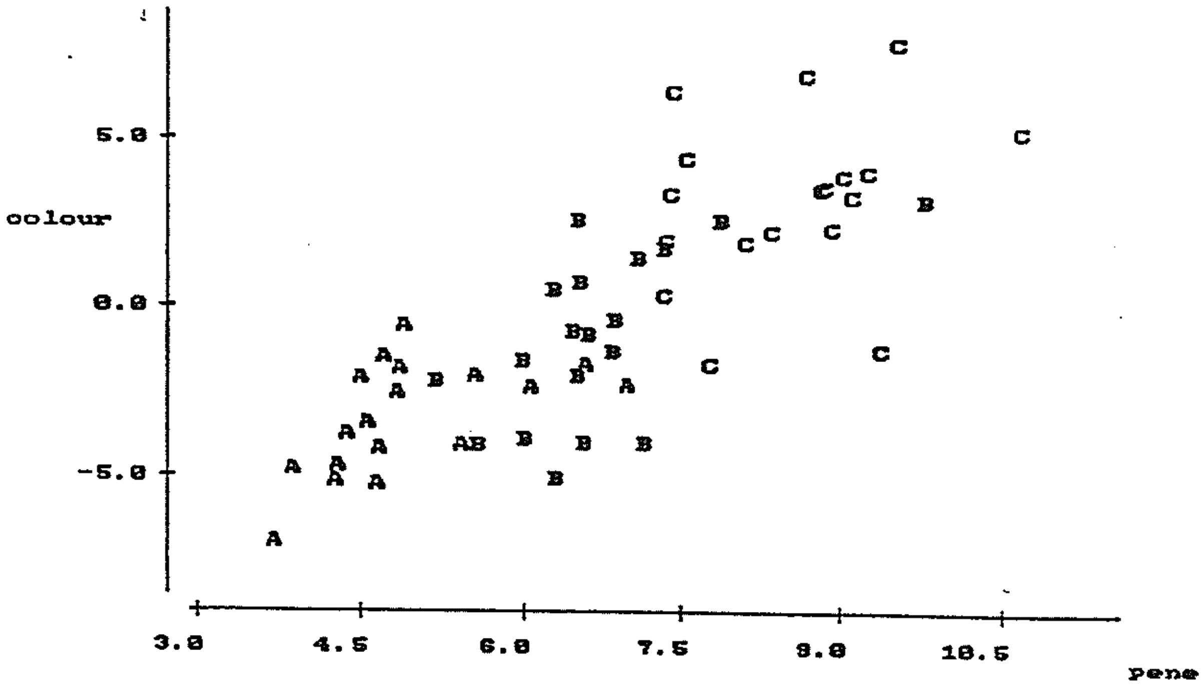
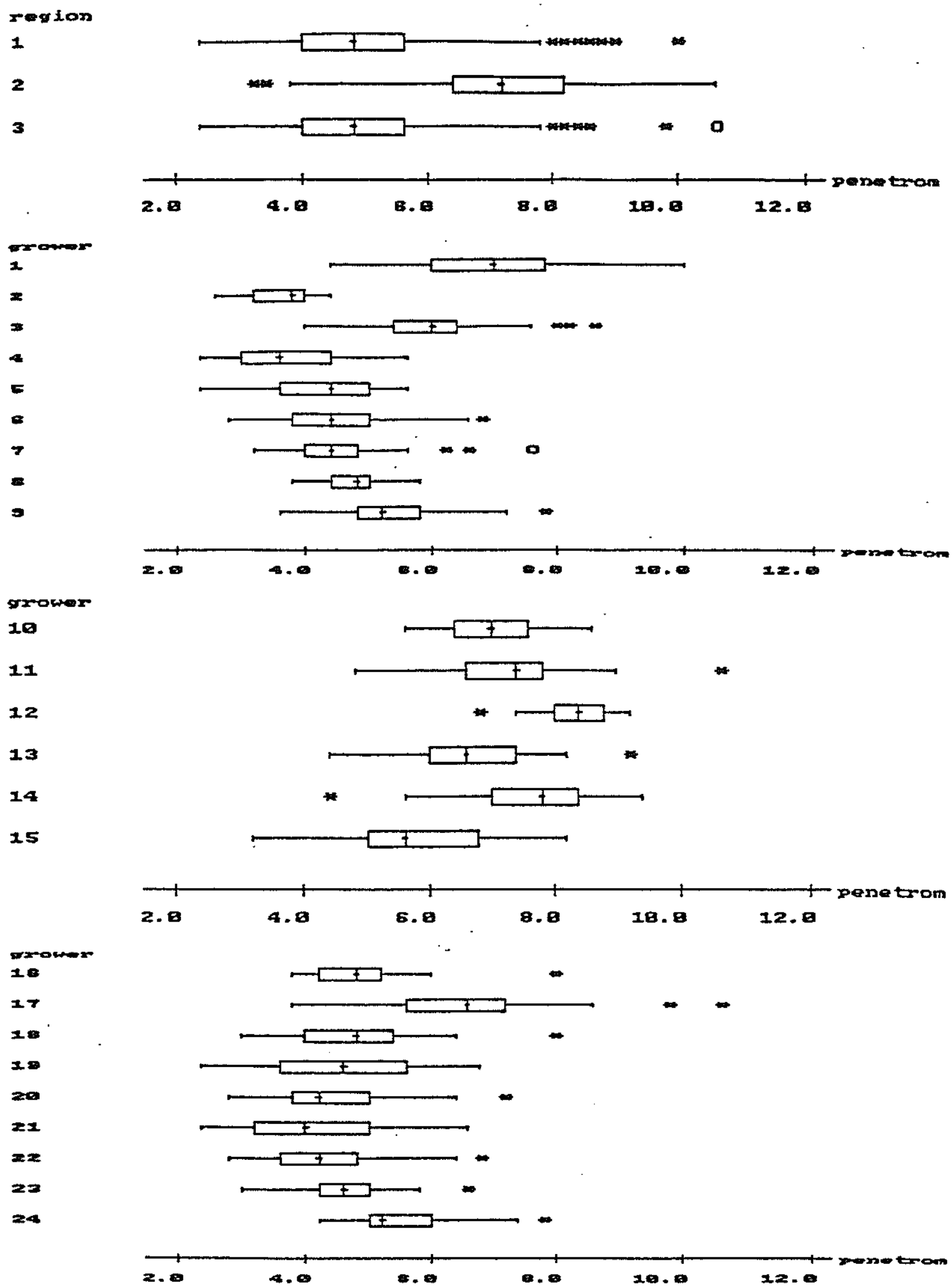


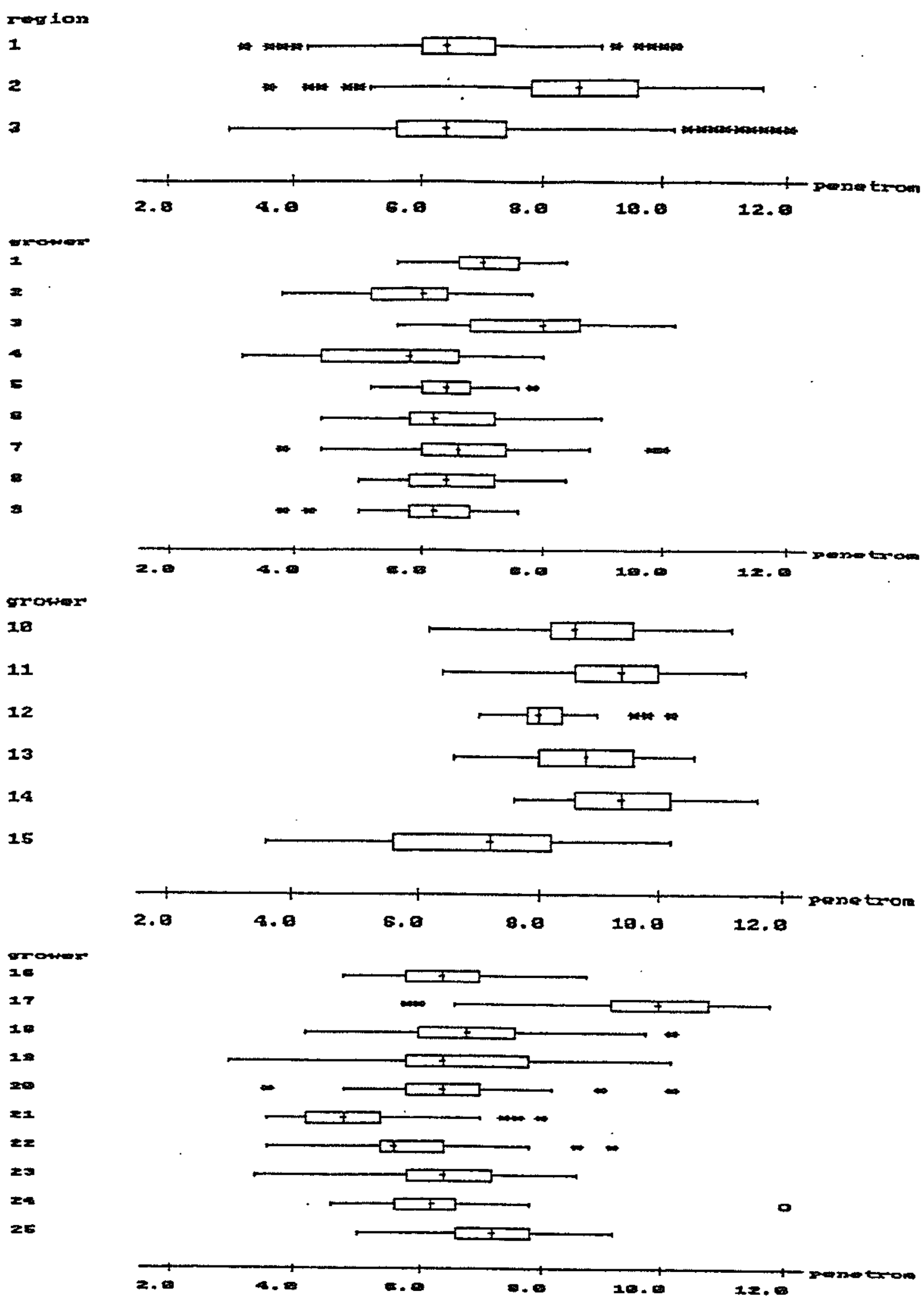
Fig 11 Site average colour values versus site average penetrometer values (Sample dates A B and C)

Appendix 1

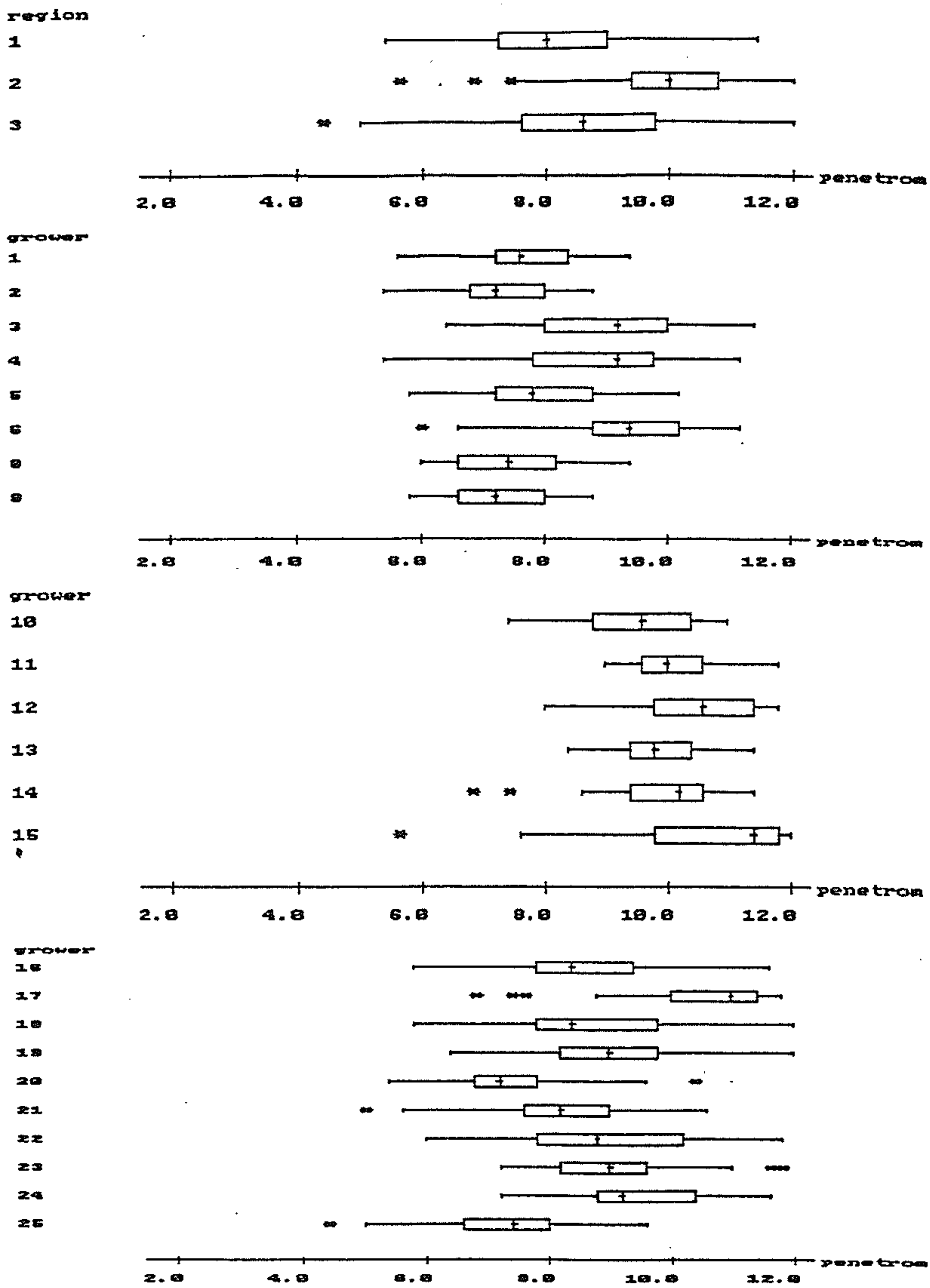
Grower	Sample 1 Corking	Sample 2 Corking	Sample 3 Corking
A	5.3	6.7	6.6
B	0.5	3.2	
C	3.1	6.6	7.2
D	0.0	0.7	
E	0.2	2.5	4.3
F	3.1	4.1	8.0
G	0.4	3.2	
H	0.4	4.6	6.9
I	2.1	3.3	6.7
South Auckland	1.8	4.0	6.6
J	2.6	4.7	7.7
K	2.2	6.8	8.8
L	2.6	4.5	7.2
M	2.5	4.6	6.8
N	3.0	4.6	8.0
O	1.9	4.2	7.2
Gisborne	2.5	4.9	7.6
P	2.1	5.9	8.8
Q	3.3	8.3	8.6
R	2.6	6.7	8.6
S	1.9	5.1	8.8
T	2.0	7.1	8.5
U	2.7	4.5	8.7
V		4.8	8.4
W	0.8	3.9	7.8
X	0.8	5.1	8.9
Y	3.5	7.6	8.2
South Island	2.2	5.9	8.5
Paddock Standard Deviations	1.6	2.1	1.2



Appendix 2: Sample A (1) site average penetrometer values for growers A - Y. (See comments for Fig 9 for explanation)



Appendix 3: Sample B (2) site average penetrometer values for growers A - Y (See comments for Fig 9 for explanation)



Appendix 4: Sample C (3) site average penetrometer values for growers A - Y (See comments for Fig 9 for explanation)

Appendix 5

SQUASH MATURITY SURVEY : PENETROMETER & COLOUR (a) MEANS

Grower	Sample 1		Sample 2		Sample 3	
	Pene-trom	Colour	Pene-trom	Colour	Pene-trom	Colour
A	7.0	-2.3	7.1	-4.0	7.8	-1.7
B	3.7	-6.9	6.0	-3.9	7.4	2.0
C	6.1	-2.3	7.9	2.6	9.0	3.9
D	3.9	-4.8	5.6	-4.1	8.9	3.5
E	4.3	-4.7	6.5	-2.0	8.0	1.9
F	4.6	-3.4	6.6	-4.0	9.4	-1.3
G	4.6	-5.2	6.8	-1.3		
H	4.8	-2.5	6.6	-0.8	7.5	4.4
I	5.4	-4.1	6.3	-5.0	7.3	0.4
South Auck.	5.0	-3.9	6.6	-2.4	8.2	1.8
J	7.2		8.9		9.7	
K	7.3		9.4		10.2	
L	8.5		8.3		10.6	
M	6.7		8.9		10.1	
N	7.7		9.6		10.0	
O	5.7		7.1		10.7	
Gisborne	7.2		8.7		10.2	
P	4.9	-0.6	6.5	2.6	8.7	6.9
Q	6.6	-1.7	9.7	3.2	10.7	5.2
R	4.8	-1.8	7.1	1.5	8.8	3.5
S	4.7	-4.2	6.8	-0.4	9.2	4.0
T	4.5	-2.1	6.5	0.8	7.4	3.3
U	4.3	-5.1	5.2	-2.2	8.3	2.2
V			6.0	-1.6	8.9	2.3
W	4.4	-3.8	6.5	-0.7	9.1	3.3
X	4.7	-1.5	6.3	0.6	9.5	7.8
Y	5.6	-2.1	7.3	1.8	7.4	6.4
South Island	4.9	-2.6	6.8	0.6	8.8	4.4
Paddock Standard Deviations	0.9		1.1		1.1	