discussion paper no. 6

The Apple Tree System
A district and grower comparison 1986/87

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FOREWORD

This report summarises the results of a co-operative research project between the Ministry of Agriculture and Fisheries, Department of Scientific and Industrial Research, New Zealand Apple and Pear Marketing Board, and the Department of Horticulture and Landscape, Lincoln College, University College of Agriculture, Canterbury, entitled: "The Apple Tree as an Economic Production Unit, A Simulation Model".

The project was commenced in April 1986 under a Post-Doctoral Fellowship Award at Lincoln College granted to Dr Piotr J Zaprzalek, Skierniewice, Poland. It was funded by a Lincoln College Research Grant and the New Zealand Apple and Pear Marketing Board.

Mr Graham F Thiele, Reader in Horticulture, Department of Horticulture and Landscape, participated in the planning and operation of the project. Mr John Wilton, Deciduous Tree Fruit Specialist, Ministry of Agriculture and Fisheries, Auckland, assisted in orchard selection, discussion on tree and orchard measurements, and by encouraging the support of advisory officers in each district. The Department of Scientific and Industrial Research helped with technicians and equipment in measuring light distribution on Hawkes Bay orchards.

Dr John Field-Dodgson, Corporate Research Manager, New Zealand Apple and Pear Marketing Board, Wellington, has maintained his interest in the project and arranged NZAPMB financial support during the harvesting season.

R N Rowe
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ABSTRACT

The aim of this study has been to assess the interrelationships of the various biological and economical factors involved in the apple tree and orchard. It has involved a systems approach to the efficiency of the apple tree as an economic unit.

To understand these interractions, a monitoring approach was used in the three main New Zealand pip fruit districts: Hawkes Bay, Nelson, and Canterbury. Five properties in each district and five Royal Gala or Gala trees on each property were used.

The following measurements and information were taken:

a. tree biological factors (tree growth, flower and fruit setting, crop load, fruit yields, and packout),

b. tree and orchard management (labour, material and capital input for the main orchard operations),

c. light distribution in the trees,

d. production economics.

The results were analysed using basic statistics, analysis of variance, and multiple linear regression to compare growers and districts, and to emphasize the main factors affecting apple tree performance. Results show clear differences between districts and growers for factors such as tree growth, flower number and fruit set, crop loading, yields, fruit size, quality and quantity, labour input and production economics (the main biological, economic and technical factors).

Nelson orchards had the highest fruit value/tree on average ($33.25), but Canterbury growers had the highest return/kg (40.3c/kg). The fruit bearing habit was clearly different between districts, with Hawkes Bay fruit near the the top of the tree and Nelson and Canterbury having a high yield on the lower tree layers.

Large differences were recorded in thinning costs with Hawkes Bay thinning mainly with chemicals, and Canterbury thinning up to 90% of the fruit from the tree by hand. The results are from one year's observations. With the dynamic nature of a fruit tree system, the preliminary regression relationships and differences established, will have to be further tested and verified. It is hoped that the work will continue during the 1987/88 and 1988/89 season in co-operation with MAF, DSIR, and the NZAPMB.

It is envisaged that the project will be completed in 1989 with the formulation of a computerised apple tree model using the recorded data from three seasons.

Royal Gala in DSIR orchard, Appleby, before first pick, 3 March 1987. Average size distribution 1.5%, 7.3% and 91.2% of size below 60 mm, 60-65 mm, and 65-85 mm respectively. Average fruit weight - 153.1 g.

Royal Gala cropping in Mr W Mottram's orchard, Prebbleton, Christchurch, before first pick on 9 March 1987. Average size distribution: 5.1%, 16.5% and 78.4% fruit of size below 60 mm, 60-65 mm and 65-85 mm respectively. Average fruit weight - 129.1 g.

1. INTRODUCTION

The value of the systems approach to decision making is receiving increasing recognition in the management of horticultural firms. Just as a firm or an orchard is a complex set of interacting factors, so too a fruit tree can be considered as a complex system of interacting factors influencing the performance of the tree. The systems approach allows the efficiency of the fruit tree to be studied as an economic unit (Figure 1).

To emphasise these interacting factors, a form of monitoring has been introduced into selected New Zealand apple orchards. The word "monitoring" has been developed in New Zealand horticulture by G F Thiele, firstly with blackcurrant producers, and subsequently, with a range of other fruit and vegetable crops (Thiele, 1983). It originated from the Swedish work, headed by Carlsson (1972) under the auspices of the TEU (horticultural management analyses) and the BET (biological, economic, technical) programmes for glasshouse and fruit growers.

Monitoring recognises that a tree or plant is a system involving a complexity of interrelating factors, growing in an interacting environment of orchard, soil and climate (the orchard system) controlled or uncontrolled by growers making individual decisions based on directly and indirectly related information (Thiele, 1986).

The aim of this paper is to analyse the main factors involved in the apple tree system as the result of one year's investigations. Subsequently, it is intended to develop a computerised apple tree model using data recorded over three seasons.

2. MATERIALS AND METHODS

Apple monitoring work was carried out in the season 1986/87. The three main New Zealand pip fruit districts have been taken into account, Canterbury (C), Nelson (N), and Hawkes Bay (HB). Although five trees on each of the 15 orchards (five in each of the three districts) were selected at random, some degree of standardization was sought to allow reasonable comparisons:

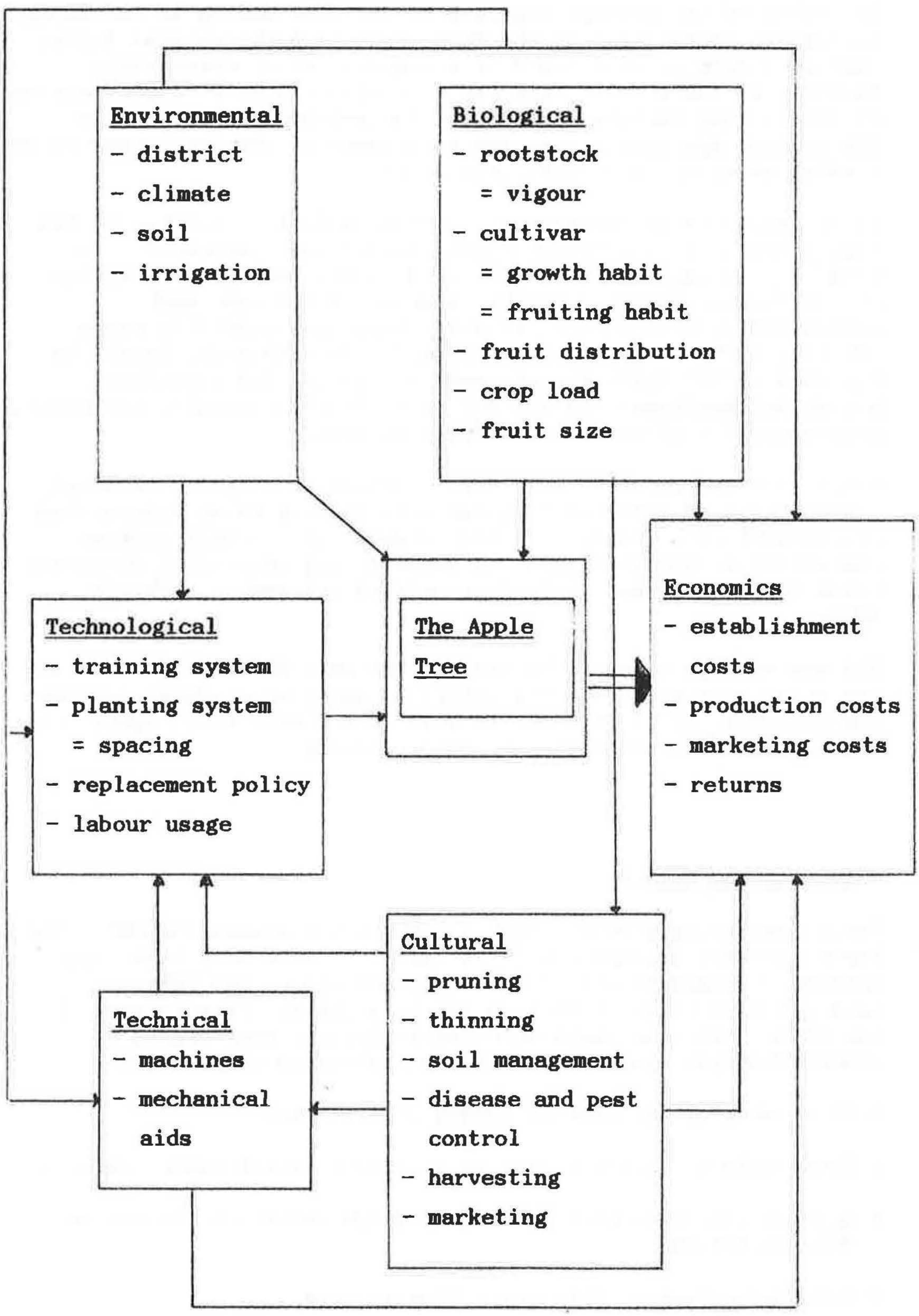
* Trees were of the central leader or axis type.

* Royal Gala or Gala was used as a representative export variety.

* Most of the trees were grafted on MM106 rootstock (three on M793 rootstock)

* Trees were four to five years from budding.

Figure 1: The Apple Tree System



Three levels were identified on each tree:

Level I - <1.2 m (from the ground)
Level II - 1.20-2.60 m
Level III - >2.60 m

The following measurements were taken:

1. Tree height from the ground to the terminal tip of the leader (m).

2. Tree width as an average between diameter across the row and along the row (m).

3. Butt height from the ground to the first limb (cm).

4. Butt circumference at about 20 cm from the point of bud union (cm) (in August 1986 and March 1987).

5. Annual and previous year's extension growth (cm).

6. Number of all arms (branches) arising from the central leader and circumference of the arms 10 cm from the trunk (August 1986). To obtain butt and total arms cross sectional area the following equation has been used:

   cross sectional area = $(\text{circumference})^2 \times 0.08$.

7. In August 1986, the circumference of the central leader was taken at the base of the terminal growth made during the 1985-86 season. A further measurement was taken in March 1987 to measure the circumference at the base of the terminal growth made during the 1986-87 season.

   Basic orchard characteristics are given in Table 3 and the height, width, and growth characteristics in Appendix 1. Tables 8.1 and 8.2.

8. It was not feasible to count the number of buds, flowers, and fruits on each whole apple tree. Accordingly, a sampling technique was devised to measure three arms on each of the five trees in each orchard to represent vertical distribution and horizontal orientation to the sun.

   Uniform arms of similar circumference from three different levels of each tree were chosen for the following measurements.

   a. Number of terminal buds.

   b. Total length of one year old laterals (longer than 5 cm), and number of buds on these laterals.

   c. Number of flower clusters.

d. Average number of single flowers/cluster (random sample of 30 flowering clusters/tree).

e. Number of fruit before and after thinning.

9. Light distribution in the selected trees in Hawkes Bay orchards.

The incoming light to different levels of the trees was measured by the Solar Monitor L1-1776 with Sensor Model quantum (L1-COR, Inc., USA) in micro Einsteins/m^2/sec. Ten measurements were taken from each level on the western and eastern sides of the tree at the same time (60/tree). Also, two measurements of the outside light at each level of the tree were taken. Sixty measurements were taken of incoming light/tree, plus six measurements of open sky light on five trees in each of five orchards, equalling 1650 measurements. Measurements were taken on 28 January 1987 in the period 10.30 am - 2.30 pm during cloudless conditions.

Additional orchard information on labour input, spray programmes and soil tests, were recorded.

Apples were harvested from each limb separately and individually weighed. They were graded according to five sizes: below 60 mm, 60-65 mm, 65-75 mm, 75-85 mm, and over 85 mm. The NZAPMB recommendations for the 1987 season were as follows:

a. Minimum "Fancy" grade colour requirements were:

Royal Gala - 66%
Regal Gala - 50%
Gala - 25%

b. Loose size range: 62-85 mm.

c. Export size range 80-175 count (62-85 mm).

d. All fruit must be submitted to the Board within 72 hours of harvest. Growers varied in the frequency of apples harvested from one to four picks. Maturity levels for harvesting were determined by the NZAPMB field staff in each district.

Basic statistics, analysis of variance, and multiple linear regression were used to compare the growers and districts, and to analyse the relationship between the main factors affecting the apple tree performance. An attempt has been made to explain the differences between the growers and districts in terms of biological, economic and technical factors.

The photographic technique has been used to record the main phenological stages of the tree development in all orchards.

The results are from only one year's observations. With the dynamic nature of an apple tree system, the preliminary relationships and differences established will have to be further tested and verified.

3. RESULTS AND DISCUSSION

3.1 Districts

Climatic data (Table 1) is representative of the following regions:

Eastern North Island – Hawkes Bay
Northern South Island – Nelson, Motueka
Eastern South Island – Christchurch, Timaru.

TABLE 1: Climatic data

District	Degree Days (°C) Base 10°C	Annual Rainfall mm	Average number of days with screen frosts		
			September	October	April
Hawkes Bay (Hastings)	1362	767	2.6	0.5	0.3
Nelson (Appleby)	1090	967	0.7	0.1	-
Motueka (Riwaka)	1039	1372	1.7	0.3	0.1
Canterbury) (Christchurch)	923	658	2.3	0.4	0.6
(Timaru)	830	601	2.2	0.3	0.3

Accumulated heat is measured by the sum of the daily temperatures above the base of 10°C. Degree days = (M-10)N where

M = mean monthly temperature.
N = number of days in the month.

All monitored orchards had live shelter.

Climatic differences between districts appears to affect tree growth habit, flower and fruit set, yields and fruit quality (size and colour). Stage of tree development each season also differs between districts (Table 2).

The 1986/87 harvesting season was about one to two weeks later than usual.

TABLE 2: **Phenological data for the 1986/87 season**

Specification	Hawkes Bay	Nelson	Canterbury	
			Christchurch	Timaru
Bud break	Mid September	Mid September	Beginning October	Early October
Full bloom	Mid October	Late October	Late October	Late October
First pick	Late February	Early March	Early March	Late March
Last pick	Mid March	Late March	Late March	Mid April

3.2 Characteristics of monitored orchards

3.2.1 Monitored blocks

Basic characteristics of the monitored blocks are given in Table 3. Most of the trees are Royal Gala trained on the central leader or axis systems.

The central leader, semi-intensive system (CL) has been the most popular method of growing apples in New Zealand recently. These orchards are normally spaced 4.5-5.0 m between rows, and 2.8-4.5 m between trees (460 to 800 trees/planted hectare).

The modified axis system (MA) is based on a training method developed in France and called "modified" because the growers have put their own ideas into the training. Trees are planted 4.5-5.2 m between rows and 2.5-3.4 m between trees (565 to 890 trees/planted hectare). All MA orchards have one or two wire support structures.

TABLE 3: Basic orchard structure

Orchard Code	Year of Planting	Variety	Rootstock	Planting System	Density (trees/ha)**	1985/86 Yield (cartons/tree)
C I	1982 R	Gala *	MM106	CL	571	4.0
II	1982 DB	Royal Gala	MM106	CL	740	2.0
III	1981 R	Royal Gala*	MM106	CL	625	3.5
IV	1982 DB	Royal Gala*	MM106	CL	740	0.5
V	1980 R	Royal Gala	M793	MA	635	3.0
N I	1982 R	Royal Gala*	MM106	MA	666	4.0
II	1981 DB	Royal Gala	MM106	MA	571	4.3
III	1980 R	Royal Gala*	M 793	CL	454	8.5
IV	1982 R	Royal Gala*	MM106	CL	740	3.5
V	1983 R	Royal Gala*	M 793	CL	800	3.0
HB I	1982 R	Royal Gala*	MM106	MA	888	6.4
II	1983 R	Regal Gala	MM106	CL	571	3.0
III	1981 R	Royal Gala*	MM106	CL	740	5.0
IV	1980 R	Royal Gala	MM106	MA	565	6.2
V	1981 R	Royal Gala	MM106	MA	625	3.0

C = Canterbury

N = Nelson

HB = Hawkes Bay

R = planted as a rod (one year old from budding)

DB = planted as a dormant bud

* = virus free trees

** = number of trees/planted hectare

MA = modified axis

CL = central leader

Orchards on relatively good soil are planted on MM106 rootstock. On poorer soil in a replant situation, M793 rootstock has been used.

The 1985/86 yields in Table 3 have been taken from growers' records to provide a background on tree performance. Orchard IV in Canterbury had a very low 1985/86 yield due to tree age and climatic conditions. The yields in orchard III in Nelson and orchard IV in Hawkes Bay, reflect that trees are two years older than most, although this was not reflected in orchard V in Canterbury. The MA system cropped slightly better than the CL system last season, notably Hawkes Bay orchard I with its high tree density.

3.2.2 Trees

An assessment of tree size and growth is reviewed in Table 8.4 (Appendix 1). Because of a slight variation in tree age, it is difficult to draw conclusions from one season's measurements, but indications are that Hawkes Bay and Nelson orchards were more vigorous than those in Canterbury.

In choosing the fruiting arms to monitor, the objective was to have uniformity of cross sectional area. The extent of the uniformity is shown in Table 8.2 (Appendix 1) as the circumference at August 1986. Growth during the season has been slightly greater at the third level as indicated by the March 1987 measurements of the same monitored arms. For example, in Canterbury, the average increase in circumference of the monitored arms at level I was 1.2 cm compared with the level III increase of 2.5 cm.

The corresponding increases for Nelson were, level I 1.0 cm compared with level III 1.3 cm and for Hawkes Bay 1.2 cm compared to 1.7 cm. By comparing butt cross sectional area (b.x.s.a.) from the beginning of the season (August 1986) until after harvest (March 1987), butt growth has been calculated. For Canterbury, Nelson, and Hawkes Bay respectively, butt growth was 33.8%, 19.4%, and 18.4%. With more dense plantings in Hawkes Bay, trees have grown more vigorously in a vertical direction. The wider spacing in Canterbury has allowed more width increase at the expense of height.

Overall there has been a greater increase in b.x.s.a. with the wider spacing in Canterbury providing the potential for a greater increase in crop loading index.

3.2.3 Spray Programme

Spray programmes used in orchards within the respective districts are shown in Tables 8.20, 8.21 and 8.22 (Appendix 2). Growers have followed MAF and NZAPMB recommendations to obtain export quality fruit. There were no notable differences between districts in the chemicals used and rates of application.

Calcium nitrate or calcium chloride has been used for bitter pit control. Thinning sprays of Septan have been used by most growers in Nelson and Hawkes Bay, and a number of growers applied nutrients in spray form.

No detailed assessment of disease and pest control was taken during the 1986/87 season, but observations indicated the control measures were nearly equally effective over all orchards. Some minor black spot infections occurred in all districts due to the higher than normal rainfall. The worst black spot occurred in orchard No. 1 in Hawkes Bay where the dense, closely-planted trees created a conducive microclimate.

Table 8.23 (Appendix 2) presents two levels of spray cost in each district, the highest and the lowest. The orchard with the lowest total direct costs was orchard No. 1 in Canterbury ($849/ha). The highest cost was orchard No. IV in Nelson ($2174/ha), a 156% increase. Furthermore, the number of spray applications varied from 14 to 22.

If the effect of these programmes is similar, in terms of marketable yield and future cropping potential, the costs are theoretically a measure of effective management. Without close monitoring data on disease and pest incidence and effect, this statement is too simplistic. The cost of spray materials varied from 52-74% of total spray costs, perhaps indicating a variation in attitude to risk by the growers. Some growers feel spray expenditure is an insurance. Overall growers had to sell about 7.5% of their fruit to cover the direct costs of disease and pest control.

3.2.4 Weed Control

All growers used chemical weed control along the rows in 2-3 m herbicide strips (Table 8.24, Appendix 2).

Most growers also applied spot applications of the following herbicides for specific weeds.

Weedazol - I*l*/100 *l*
Simazine - 40ml/10 *l*
Fusilade - 30ml/10 *l*
Roundup - 150ml/10 *l*

Weed control in most orchards was satisfactory.

3.2.5 Fertilisers

Soil test results have been recorded for most Canterbury and Nelson orchards and are held for future reference. No soil tests were taken by Hawkes Bay orchardists.

According to Wilton and Clark et al (1986), many Hawkes Bay orchards are on deep, fertile, alluvial soils which are well supplied with nutrients. These soils are able to maintain heavy cropping with little or no applied fertilisers.

Fertiliser applications for Canterbury and Nelson orchards are given in Table 8.25 (Appendix 2). No fertilisers were applied in the Hawkes Bay orchards.

All orchards have regularly mown grass between the rows with herbicides used in two to three metre strips along the rows.

Growers appear to have correctly followed soil test results and MAF recommendations. Some growers have also used foliar applications and liquid fertilisers through the trickle irrigation system. Most orchards have maintained a pH range of 5.8 - 6.8 as suggested by Clark et al (1986) for pip fruit. These authors also recommended that soil test values for Ca, K, and Mg should be in the ratio 1.6-2 : 1 : 2.

They advocated, for soils of average fertility, annual rates as high as 300 kg N/ha, although 80-120 kg/N/ha should be sufficient in most circumstances. On soils of low fertility they recommend application rates of 10-15 kg N/ha/10 tonne of crop once plateau yields have been reached (Table 8.26, Appendix 2).

3.2.6 Irrigation

All monitored orchards have been irrigated during the season 1986/87.

Growers have used the following irrigation systems:

a. Sprinkler irrigation (both overhead and under tree) (C/V, N/II, HB/II, V).

b. Under-tree microjects or microsprinklers (C/II, N/I, V, HB/I, III, IV).

c. Under-tree drippers (CIII, IV, N/III, IV).

d. Under-tree microtubes (C/I).

Canterbury growers have irrigated during the whole growing season. Nelson growers irrigated from October until February, and Hawkes Bay growers irrigated mainly from February to March. Growers have to consider soil types and water budgeting (evapotranspiration) to determine the amount of water required. No attempt has been made to monitor soil moisture levels on a water budget basis during the 1986/87 season.

According to MAF, Christchurch (1985), the average daily moisture loss by months in Canterbury is as follows:

September - 2.1mm/day
October - 2.9mm/day
November - 3.5mm/day
December - 3.8mm/day
January - 3.8mm/day
February - 3.4mm/day
March - 2.6mm/day
April - 1.7mm/day
(1mm on 1 hectare = 10,000 litres)

During hot north westerly conditions the daily soil moisture loss can be double the average monthly figure.

According to Jackson (1986) there are two methods of estimating water needs/tree:

1. Water needs/tree in litres = evapotranspiration in mm x proportion of leaf cover x 10,000 ÷ trees/hectare.

2. Water needs/tree in litres = 2 x diameter of tree in meters x evapotranspiration in mm.

3.3 Relationship Between Butt Cross-sectional Area and Total Arms Cross-sectional Area

Various researchers (Costa and Grandi 1982, Dennis 1981, Forshey 1977, and Miller 1985) have used sampling procedures based on selected fruiting arms to extrapolite measurements to a whole tree basis. In each case the sampling method has not been justified.

Accordingly, an attempt was made to relate the butt cross sectional area (crop potential), to a fruiting arm cross sectional area basis. A significant linear relationship has been established between total arms cross sectional area and butt cross sectional area with the 75 trees monitored. The correlation coefficient was 0.662 (Figure 2).

This relationship has been used to justify the use of selected fruiting arms for bud, flower, and fruit counts, and is extremely important in convincing growers of the time/benefit relationship of the recordings.

3.4 Number of Terminal Buds

3.4.1 Terminal and one year old lateral buds

Flower bud initiation and development have been documented by a number of authors (e.g. Jackson 1972, Grabbe 1984, and Tromp 1984).

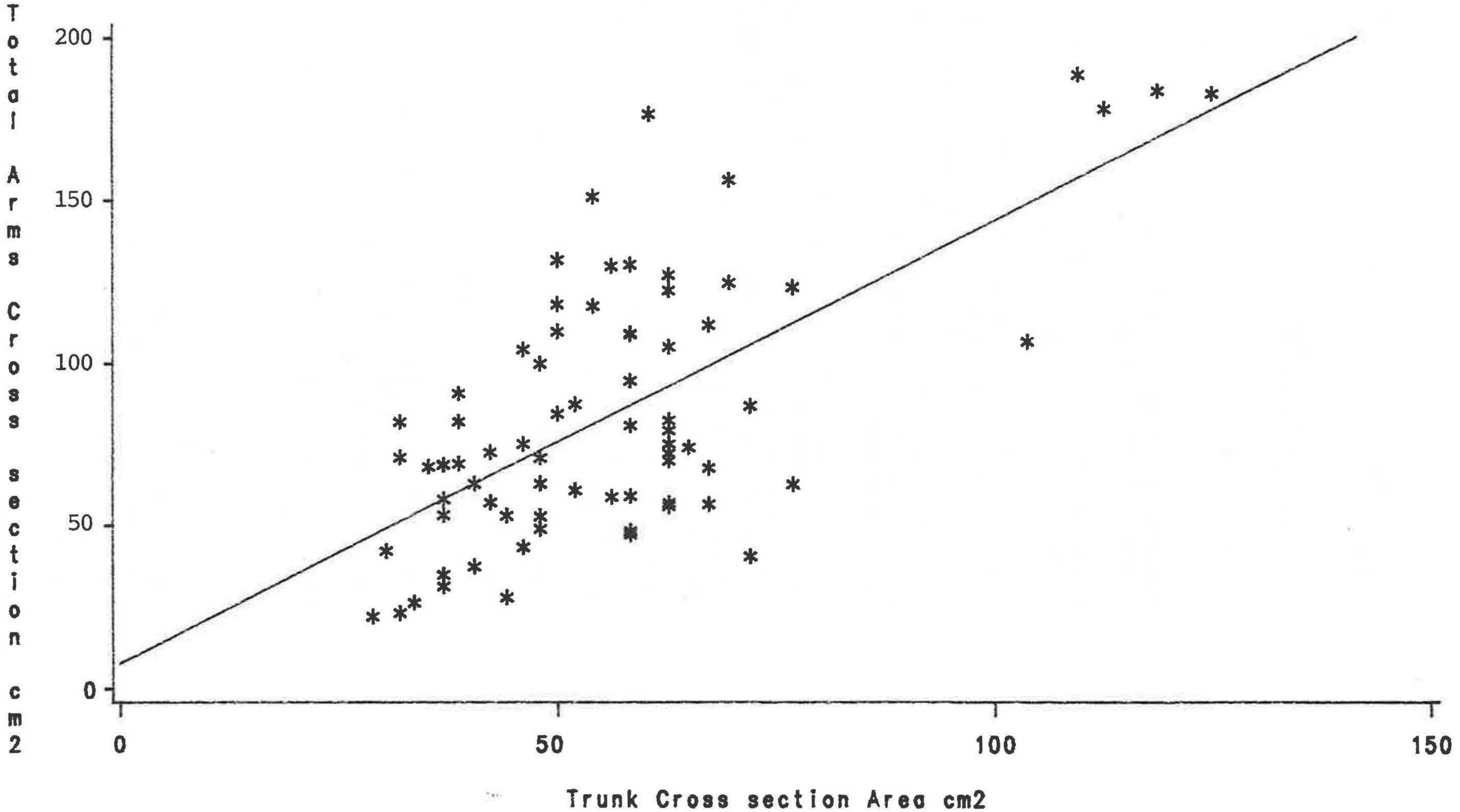
Clearly, initiation and development of apple flower buds takes place between leaf formation in the spring and leaf fall. The process is influenced by both physiological and environmental factors. The grower can exert some control by balancing crop loading in one year with bud initiation for the following years. Fertilising, irrigating, pruning, thinning and spraying can all have some influence on flower bud initiation.

The best quality apples are produced on the terminal buds of one year old wood and the lateral buds on two and three year old wood (Wilton, 1980). This emphasises the importance of growers recognising the positioning of flower buds and the control of their formation and distribution on a tree. Bud distribution and numbers for the monitored trees are given in Tables 8.3 and 8.4 (Appendix 1).

Analysis of variance between numbers of terminal buds/1cm^2 of arms cross sectional area from the three levels indicates:

Figure 2: Relationship between Trunk Cross–sectional Area and Total Arms Cross–sectional Area – All Districts

Correlation Coefficient : 0.662



* there are highly significant differences within districts.

* in all districts the number of terminal buds decreases from Level I to Level III.

* Nelson orchards had a higher number of terminal buds/1 cm^2 in Level I than Hawkes Bay or Canterbury.

* Hawkes Bay orchards had significantly more buds at Level III than the other two districts.

* Canterbury orchards had the lowest terminal bud numbers for both Levels II and III.

One year old wood measurements and the number of lateral buds on this wood are given in Table 8.4 (Appendix 1). One year old laterals on Gala apple trees provide potential fruit-bud sites for the current and the following season and may or may not initiate flowers.

Canterbury orchards had the greatest length of one year old wood on the lower tiers; 298 cm for Level I, 194 cm for Level II and 158 cm for Level III. On average the reverse situation applied in Hawkes Bay orchards; 118 cm for Level I, 172 cm for Level II, and 256 cm for Level III.

In Nelson, Level II had the lowest length of one year old laterals; 317 cm for Level I, 213 cm for Level II, and 231 cm for Level III.

There were marked differences from the average situation within districts. For example, orchard V in Canterbury demonstrated the typical Hawkes Bay pattern with more one year old growth in Level III.

Orchard II in Nelson showed the typical Canterbury pattern, a reflection of the centre leader rather than the axis training system used in this orchard.

The Hawkes Bay figures reflect the vigorous top growth habit typical for close planted Axis-trained trees in this district.

The number of buds/10 cm of lateral showed no significant differences between levels in all three districts (Table 8.4, Appendix 1). In fact, in Nelson and Hawkes Bay, the figures for the three levels were almost identical, although in Canterbury, the number of buds/10 cm of laterals was significantly higher than Nelson or Hawkes Bay. The average for all three levels was: Canterbury 3.4, Hawkes Bay 2.8, and Nelson 2.4.

3.4.2 Terminal buds versus fruit quality

The assertion by Wilton (1980) that one year old wood produces the best quality fruit is confirmed for Nelson and Canterbury orchards (Table 8.5, Appendix 1). The more terminal buds/1 cm^2 of arms cross sectional area, the more export quality fruit 65-85 mm size produced/1 cm^2 of arms cross sectional area.

The vigorous growth towards the top of Hawkes Bay trees appears to have altered this pattern with a greater number of export fruit produced on the upper (third) level. Hawkes Bay trees could be described as "umbrella shaped" whereas, in general, Canterbury and Nelson have the typical central leader shaped tree.

The ratio of terminal buds to export sized fruit was always higher at the lower levels (2.13, 2.08, 3.12 in Canterbury, Nelson, and Hawkes Bay, respectively).

One export quality apple harvested from the third level needed 1.7, 1.5, 1.3 terminal buds in Canterbury, Nelson and Hawkes Bay respectively, indicating greater efficiency at the top of the tree. No relationship was established between the number of terminal buds and the weight of individual fruit. Fruit weight is a function of fruit number and fruit number is a function of flower number and fruit set together with the degree of thinning. These parameters will be investigated in later chapters.

3.5 Fruiting Potential

Flowering is influenced by both physiological and environmental factors documented by a number of authors (e.g. Jackson, 1972 and 1986, Grabbe 1984, Jonkers 1984 and Tromp 1984). According to Abbott (1984), full-bloom can be expected to occur when the mean temperature is above 11°C. Flowering has occurred at different times in monitored orchards, mainly because of climatic differences (Table 2).

The flower cluster is usually borne on a short shoot or spur on two year or older wood, or terminally and sometimes laterally on one year old wood (Abbott, 1984). Flower clusters on Royal Gala trees quite often develop on one year old laterals.

Details on flower number and flowering buds are given in Tables 8.6 and 8.7 (Appendix 1).

The number of single flowers in flower clusters did not differ significantly between tree levels, between districts, or between growers.

The number and distribution of flower clusters varied greatly between growers and between districts, but it is difficult to determine a significant pattern, which indicates the effect of individual training and husbandry practices.

In Canterbury and Nelson, the lower levels generally had more flower clusters. In Hawkes Bay, there were exceptions to this rule, notably orchard IV which had 41 clusters on the third level compared with only 21 clusters on the second level, and 28 on the lowest level.

Table 8.7 (Appendix 1) indicates a high level of flowering buds as a percentage of total buds in Nelson orchards (>50% on average), but there are significant differences between orchards (compare Nelson I - 75% average with Nelson III - 20% average).

Similar differences occurred between growers in the other two districts. The vigour of the Hawkes Bay orchards is reflected in the lowest average percentage (30%) in the upper level of the tree.

Comparisons between the number of flower clusters and fruit size do not show significant differences, but the number of fruit harvested/100 clusters indicates that the third level has the potential to produce the highest number of fruit, especially in Hawkes Bay (Table 8.8, Appendix 1).

Fruit size distribution within trees and between districts will be dealt with in section 3.9.

3.6 Fruit Set

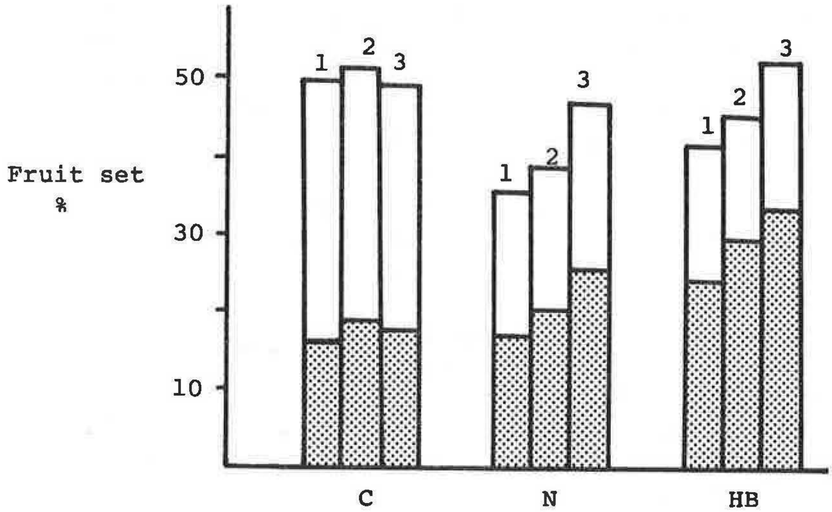
Those flowers which were inadequately pollinated were shed during the first drop to leave an initial fruit set recorded about three weeks after full bloom. Fruit abscission was generally complete by about 9-10 weeks after full bloom, when the final fruit set was recorded.

The differences between initial and final fruit set can be attributed to summer drop, wind and thinning.

Although initial fruit set was higher in Canterbury 50%, compared with Nelson 40%, the final fruit set figures showed Canterbury the lowest at 17%, Nelson 21% and Hawkes Bay 29% (Figure 3). Final set as a percentage of initial set was only 35% in Canterbury compared with 62% in Hawkes Bay and 51% in Nelson. The greater use of chemicals for thinning in Hawkes Bay and Nelson could partly explain these differences.

Fruit setting is influenced by many factors. Some of these, such as solar radiation, percentage of flowering buds and

Figure 3: Average fruit set



1 - Level I (<1.2m)
2 - Level II (1.2-2.6m)
3 - Level III (>2.6m from the ground)

Final Fruit Set

Initial Fruit Set

Fruit removed by hand thinning and natural drop

C - Canterbury
N - Nelson
HB- Hawkes Bay

growth regulators as related to branch angle have been discussed by Dennis (1981) and Voltz (1982). The availability of pollinators and bee activity are other critical factors.

A major ommission from the records kept was the absolute weight of fruit harvested from each level and an absolute measure of the quality of that fruit. It is hoped that growers will keep these records for the monitored trees in future seasons. The co-ordinators of the monitoring could not handle this work in the 1986/87 season.

It is clear that harvesting fruit from ground level will reduce harvesting costs. Some growers (e.g. Canterbury II, III; Nelson, III, V) harvested the majority of fruit from Levels I and II. Most of the fruit harvested in Hawkes Bay orchards was from the upper Level III.

More work is needed on fruit distribution in relation to potential crop loading and this needs to be related to fruit quality and return/tree after harvesting costs.

Fruit was harvested from the monitored arms on two to four occasions, then counted and hand graded. The results are shown in Figure 4. The modal size class was the same in all districts (65-75 mm). This class together with the 75-85 mm size class represents export quality. There were no significant differences in export quality from the two size groups between districts (Hawkes Bay - 80.1%, Nelson - 77.3% and Canterbury - 77.8%).

Average fruit weight in Hawkes Bay was 7.4% higher than Canterbury fruit and 8.2% higher than Nelson fruit. Average fruit weight did not differ significantly between the tree levels (Table 8.9, Appendix 1).

3.7 Thinning

The key objectives of thinning are:

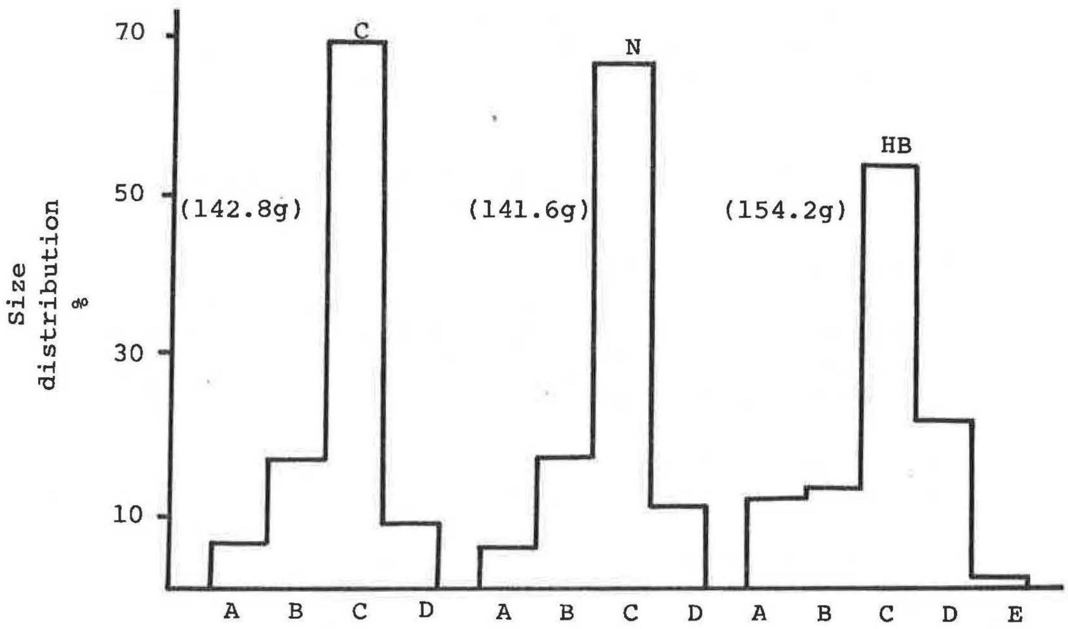
* to maximise tree return based on number of fruit, distribution and export size requirements.

* to balance crop load with tree growth to provide the basis for future yields.

Early thinning ensures maximum benefit. Growers usually base thinning strategies on tree size, vigour and past performance.

Much work has been done on thinning targets for both stone and pip fruits including that by Lamb (1972), Abbott (1984), Miller (1985), Rowe (1985), Hill (1986), Jacyna and Trappitt (1986).

Figure 4: Fruit size distribution in size classes in districts



A B C D E
<60 60-65 65-75 75-85 >85mm (142.8g) -Average fruit weight in g.

Some of the principles suggested by these authors include:

* Unthinned trees have heavy crops of very small fruit and have a heavy natural drop.

* Thinning Cox's Orange Pippin to a target of six fruit/cm^2 of butt x sectional area gave the greatest number of fruit.

* The number of fruit retained on each branch should be proportional to the cross-sectional area of that branch.

* Reduction of fruit number is usually associated with a yield decrease, but an increase in average fruit size. Larger fruit reduces harvesting costs.

* Increasing fruit size by thinning is usually at the expense of total yield, but not necessarily at the expense of profitability. Thinning usually results in a higher export packout.

* The effectiveness of thinning must also be measured in terms of flower initiation for the following season.

Most growers used both hand and chemical thinning. One grower in each district did not thin at all. After chemical thinning the growers usually hand thinned to remove damaged, diseased and misshapen fruit, and to adjust fruit number to the potential for each tree (Table 8.10, Appendix 1).

The percentage of fruit removed by the various growers varied to such an extent that any analyses of the mean figures would not be warranted. In contrast, the percentage of fruit removed by each grower at each tree level was very similar. Tree age and size, thinning method and growers' objectives, all affected the number of fruits removed by hand.

The relationships involved in thinning, crop loading, and fruit weights will be considered in Section 3.10.

3.8 Light Interception

The main factors affecting light penetration in fruit trees are:

* Leaf area.

* Tree shape, size and spacing.

* Number of branches.

* Row orientation.

* Angular distribution of light from the sun.

Jackson (1980) and Palmer (1980) have found that the light intercepted by trees depends on the leaf area and the arrangement of that area in space. For any given leaf area, increasing the height of the tree increases light interception. Tree size and spacing are particularly important at high leaf area levels (Palmer, 1980).

Usually light levels are higher in the upper part of the developed canopy (Campbell, 1986; Ferree and Hall, 1980; Palmer, 1980; Warrington, et al 1986). The pyramid shape allows good light penetration, but shading effects might occur on lower branches (Warrington et al 1986; Wilton, 1980). The number of branches and fruit within the tree crown affect light penetration as well (Palmer, 1980).

Row orientation and aspect have been reported by Jacyna (1980) and Palmer (1980) as important factors. Apples from the west side of rows planted north-south were of higher quality than from the east side. Light penetration depends also on angular distribution of light from the sun (Palmer, 1980).

Factors affecting light penetration can mostly be controlled by the grower introducing suitable tree training and planting systems. Low light can affect:

* Flower initiation and setting
* Yield
* Fruit quality (size, colour).

Jacyna (1980) advocated that the better the light penetration within the tree crown, the more buds flowering and the better the fruit set. Both Jackson (1978) and Jacyna (1980), suggested that total yield of fruit is a linear function of sunlight available. Jacyna indicated that faster ripening and a greater weight of fruit resulted from greater exposure to sunlight on rows running north-south. However, Palmer (1980) noticed that light penetration gives only an indication of the potential yield of an orchard; the actual yield can be less if there is serious within-tree shading.

Campbell (1986) found that when the light intensity falls below 25% there is a sharp drop in fruit size, and when reduced to less than 40% there is poor fruit colour.

Significant variation in light distribution in five of the monitored orchards (in Hawkes Bay) is shown in Table 4.

Grower I had significantly less light in the first and second levels than the other growers. The trees are only about 2 m apart and have developed a strong growth pattern near the top of the trees. These trees are also very tall for their age (5.15 m at five years old). Grower IV has similar trees although the wider spacing at 3.5 m allows more light into the first level.

TABLE 4: Percentage light in Hawkes Bay orchards*

Orchard Code	Tree Height(m)	Tree Levels		
		I	II	III
HB/I	5.15	3.5	10.6	43.7
II	3.81	13.6	29.9	54.6
III	4.47	16.2	36.5	54.0
IV	5.10	12.8	16.5	50.0
V	4.52	19.9	29.8	43.1
Mean	4.61	13.2	24.7	49.1

*An average from five trees for each grower.

The light measurements are similar to those published by Campbell (1986), Palmer (1980), and Warrington et al (1986) (Figure 5).

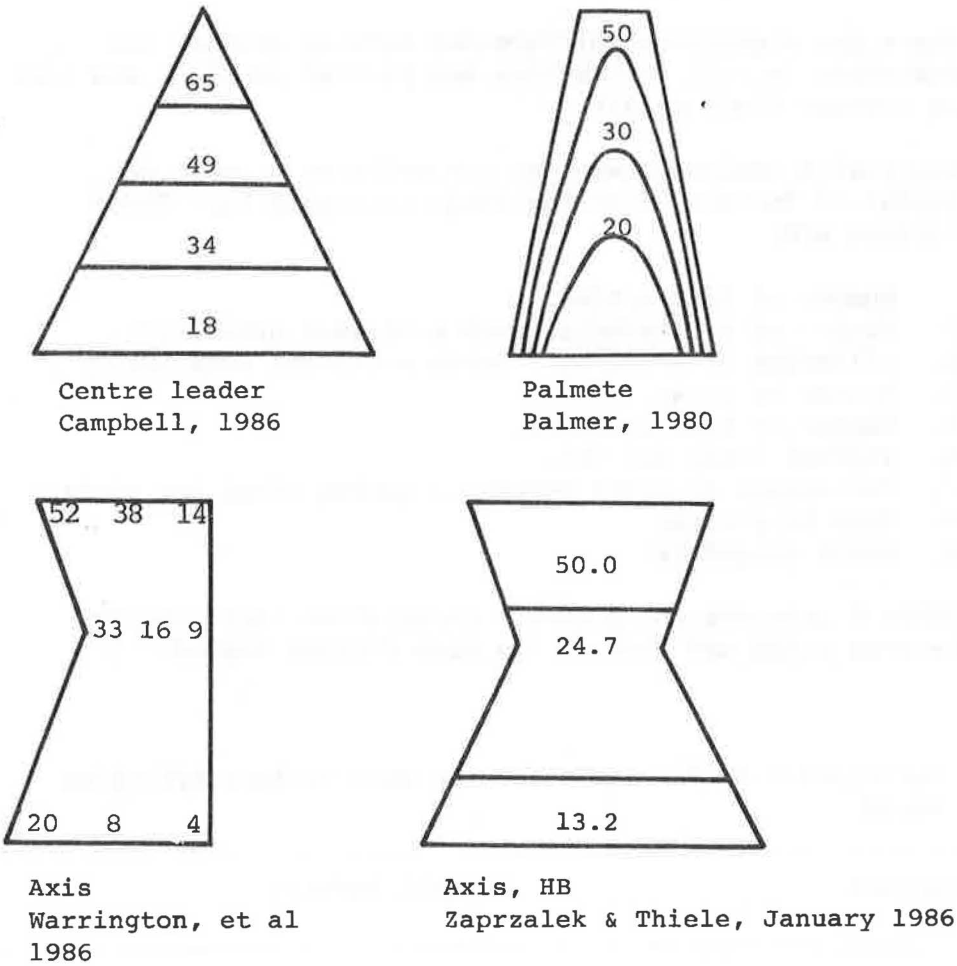
There was no significant correlation between incoming light to the tree canopy and fruit size distribution (Table 8.11, Appendix 1). The negative correlation coefficient between light and yield indicates the need for more thorough investigation in future seasons. The fact that the correlation coefficients measuring the effect of light on fruit size and weight at level I are approaching 0.5 indicates the need for further detailed measurements. Orchards I, III and IV in Hawkes Bay have developed heavy branches and growth near the top of the trees. In these cases the "umbrella" shape has tended to promote more fruiting near the top of the tree and a lower yield and poorer fruit quality at the lower levels. These observations need to be continued by more detailed crop assessment at the various levels in future seasons.

3.9 Yields and Fruit Size Distribution

Yield is a function of the number of fruits harvested and the size of individual fruits. It is the end result of orchard management parctices discussed in the previous chapters. Many authors have discussed the factors affecting apple yields including Forshey (1977), Webster (1980), Dennis (1981, 1983), Hansen (1982), Nagle (1985), and Rowe (1985).

Although yield is affected by agronomic factors the important parameter is return/tree (or planted hectare) as affected by market packout.

Figure 5: Light intensities (%) within the canopy obtained by different authors



Crop loading index (CLI) is also an important parameter which allows the grower to assess the effect of management practices independent of tree size.

CLI = Yield (kg or number of fruits)/1 cm^2 of butt cross sectional area.

Yields and fruit size from monitored orchards are shown in Tables 8.12-8.14 (Appendix 1).

There are significant differences between growers and districts in both yields/tree and planted hectare, and also in average fruit weight.

Regression analyses has been conducted on a range of potential factors affecting yield (Appendix 3). These factors are:

1. Number of fruits/tree.
2. Number of fruits/butt cross sectional area (CLI).
3. Kilograms of fruit/butt cross sectional area (CLI).
4. Number of picks.
5. Number of trees/hectare.
6. Initial fruit set (%).
7. Percentage of fruit harvested during first two picks.
8. Tree height (m)
9. Fruit weight (g)

Table 5 provides the district correlation coefficients between yield and each of the nine factors tested.

TABLE 5: Correlation coefficients for the main factors affecting yield

No.	Factors	Yield kg/tree		
		C	N	HB
1	Number of fruit/tree	0.951	0.962	0.971
2	Number of fruit/butt x.s.a.	0.706	0.726	0.514
3	Kg fruit/butt x.s.a.	0.678	0.752	0.384
4	Number of picks	0.631	-0.130	0.517
5	Number of trees/ha	-0.542	-0.297	-0.297
6	Initial fruit set %	0.532	0.350	0.456
7	% of fruit harvested during the first two picks	-0.427	0.278	-0.853
8	Tree height (m)	0.025	0.814	0.474
9	Fruit weight (g)	-0.257	-0.415	-0.515

* Clearly number of fruit/tree is closely correlated with yield/tree as would be expected.

* Number of fruit and weight of fruit/butt cross sectional area are correlated with yield in Canterbury and Nelson, but the relationship in Hawkes Bay is not as positive.

  Similar results to these three factors have been reported by Forshey (1977), Hansen (1982), Dennis (1983), Abbott (1984), Miller (1985), Rowe (1985), Jacyna and Trappitt (1986), and Nagle (1986).

  The reason why yield is not significantly correlated with butt x.s.a. in Hawkes Bay is not clear. It is possible that crop loading in Hawkes Bay is below potential levels as indicated by butt x.s.a.

  * Number of picks during harvesting time is significantly related with yield in Canterbury and Hawkes Bay orchards. The reason it did not appear in Nelson is probably the small variation in number of picks.

  * Number of trees/hectare was closely related to yield only in Canterbury orchards. This significance occurred presumably because of the greater planting density variation in Canterbury.

  * Initial fruit set is significantly related to yield in Canterbury orchards. This relationship has been reported before by Dennis (1981).

  * Tree height was highly related with yield only in Nelson orchards.

  * Fruit weight was negatively correlated with yield in all districts, but only significant in Hawkes Bay orchards. This relationship has been reported by others such as Costa and Grandi (1982), Hansen (1982), Abbott (1984), Rowe (1985), and Jacyna and Trappitt (1986). However, Dennis (1981) concludes that fruit weight can be either negatively or positively correlated with yield which reflects the negative correlation between fruit load and fruit size.

  * Highly significant correlation has been found between yield/tree and percentage of fruit harvested during the first two picks in Hawkes Bay orchards.

The nine factors considered have explained 99.6%, 99.8% and 99.8% of yield variation in Canterbury, Nelson, and Hawkes Bay respectively. Statistical significance does not imply necessarily that a variable will be economically important, but it suggests what a grower may take into account in attempting to improve yield.

3.10 Crop Loading

One of the main problems in apple tree management is how to achieve optimum balance between fruit number, fruit size and tree growth to maximise net return. The crop loading index (CLI) is expressed in terms of weight of fruit/cm^2 of butt cross sectional area measured 20-30 cm above the bud union in late winter. Theoretically, having determined the potential carrying capacity of a tree based on butt size, it is possible to target fruit numbers to produce a required optimum fruit size based on market requirements.

A summary of the factors associated with crop loading is given in Table 8.15, Appendix 1. The importance of the CLI in fruit tree management has been pointed out by many authors including Lamb (1972), Forshey (1977), Costa et al (1982), Hansen (1982), Dennis et al (1983), Abbott (1984), Miller (1985), Rowe (1985), Jacyna and Trappitt (1986).

3.10.1 Relationship between butt cross sectional area and yield

Webster and Brown (1980) have reported a linear correlation between butt cross sectional area (x.s.a.) and yield. This relationship is confirmed with the monitored orchards (Figures 8.1 and 8.2, Appendix 3).

The correlation coefficient for all yields and butt x.s.a. (three districts with 75 trees) was 0.694 and the regression coefficient was highly significant at the 0.01 level. The highest correlation coefficient was found for Hawkes Bay orchards (0.813; R^2 = 74%). There was no significant correlation in Canterbury orchards.

3.10.2 Relationship between yield and number of fruit/tree

There was a highly significant correlation between these two predictors (Table 5, Figures 8.3 and 8.4 Appendix 3); the higher the number of fruit/tree the higher the yield. This is to be expected for trees not loaded to their full potential.

Theoretically, if the crop loading index concept applies, yield would reach a plateau. At this point any increase in fruit numbers would result in a corresponding reduction in fruit size. Accordingly a high correlation has occurred between yield and the crop loading index (Figures 8.5 and 8.6 Appendix 3).

3.10.3 Relationship between fruit weight and crop load

A negative correlation has been found between fruit weight and crop loading index within districts and for the whole tree population (Table 5, Figure 8.7 Appendix 3). This means that the higher the CLI the lower the fruit weight. Increasing fruit size by thinning is at the expense of crop loading. The highest relationship has occurred in Nelson orchards where correlation and regression coefficients were highly significant (R^2 = 53%). The negative relationship between fruit weight and the crop loading index is obvious and agrees with results obtained by others, such as Forshey (1977) Dennis (1983), Rowe (1985), Jacyna and Trappitt (1986), etc.

3.10.4 Other factors related to crop loading

There was a correlation between the crop loading index and fruit size distribution in the monitored orchards (Table 6, Figure 8.8 Appendix 3). The size group 65-85 mm was negatively correlated to crop loading, but the regression coefficient was not significant in Canterbury orchards. This means that the higher the crop loading, the lower the percentage of export-sized fruit for trees in Nelson and Hawkes Bay.

Table 6: Correlation coefficients for other factors related to crop loading

Factor	Canterbury	Nelson	Hawkes Bay
Export fruit size			
65-85 mm %	-0.216	-0.730	-0.763
60-65 mm %	0.152	0.658	0.732
Reject %	0.300	0.688	0.625
% Flowering buds	0.088	0.586	0.623
Initial fruit set	0.572	-0.051	0.227
Final fruit set	-0.163	-0.321	-0.284

Crop loading was positively correlated for the 60-65 mm and below 60 mm sized groups in Nelson and Hawkes Bay.

This relationship could be expected in conjunction with the relationship between crop loading and fruit weight (especially in terms of export fruit size). A similar relationship has been reported by Dennis (1983), and Jacyna and Trappitt (1986).

Correlation coefficients for the percentage of flowering buds and fruit set also indicate a possible relationship with the crop loading index. However, apart from the percentage of flowering buds in Nelson and Hawkes Bay, other regression coefficients are not significant.

Other masking factors within districts is the only explanation that can be offered for this discrepancy. It has been reported in the Long Ashton Annual Reports (1974-1981) and Abbott (1984) that fruit number is a function of both the amount of blossom and fruit set. This is an obvious expectation, but thinning strategies naturally have an effect on final fruit number.

3.10.5 Using CLI in practice

The advantage of using the CLI in orchard management has been discussed by many authors including Forshey (1977), Dennis (1983), Abbott (1984), Miller (1985), and Rowe 1985).

It allows the grower to compare the real effects of management practices on cropping. Using the CLI it is possible to compare cultivars with significantly different growth forms and vigour, planted in different years.

The optimum crop load is a measure of return/tree as distinct from yield/tree. The optimum lies somewhere between low numbers of large fruit (and possibly lower yield) and high numbers of smaller fruit (and possibly higher yield). The return/tree depends on the price the market is prepared to pay for fruits of various sizes (and quality).

It is really necessary to take into account the whole management system and consider net return/tree by incorporating thinning, harvesting and other variable husbandry costs associated with fruit size and yield. These relationships are summarised in Figures 8.10, 8.11 and 8.12 (Appendix 3).

To apply the CLI concept in practice it would be necessary for the grower to measure the cross sectional area of the butt of each tree at thinning time and calculate the potential yield for that tree (assuming the maximum CLI for that variety is already known). The potential yield can then be divided by the optimum weight of individual fruits, as determined by market requirements, to calculate the number of fruits to be left on the tree.

In practice, thinning accurately to a predetermined number of fruit/tree, will be a matter of sample counting until such time as visual accuracy can be achieved. The monitored growers realise the importance of applying the CLI concept and agree that further monitoring work is necessary to perfect a CLI chart for Royal Gala in each district and eventually for all varieties.

Perfection of crop loading techniques in practice is also very important for the NZAPMB and servicing industries in providing the basis for more accurately estimating packaging, storage and shipping requirements.

3.11 Economics

3.11.1 Labour consumption

Fruit growing has always been labour intensive: pruning and training, general cultural operations, pest and disease management, fruit thinning, and harvesting and handling. Over the years, labour has been replaced by greater investment in machines and chemicals.

Average labour consumption in the monitored orchards for the 1986/87 season is shown in Table 8.16 (Appendix 1). Only small differences have occurred between districts. On average, Nelson growers used 18% more person-hours/ha and Hawkes Bay growers 8% less than Canterbury growers.

The main reason for the difference is the lower input of labour for hand thinning in Hawkes Bay orchards where chemical thinning is a common practice. The 30% of direct labour costs spent on hand thinning in Canterbury and Nelson contrasts strongly with the 0.3% cost in Hawkes Bay.

Tree size and density and crop loading also influenced labour cost to some extent. The larger trees in Hawkes Bay caused a higher cost of pruning/ha. The pruning cost was 15.6% of total direct labour costs in Hawkes Bay, 11.5% in Nelson and 10.2% in Canterbury.

Pest and disease, weed control, fertilizer application and other operations made up 10.5%, 11.7% and 12.5% of total direct labour costs in Canterbury, Nelson and Hawkes Bay orchards respectively. Hawkes Bay orchardists did not apply fertilisers which further emphasises the additional labour cost of chemical application in Hawkes Bay.

Although Hawkes Bay growers spent 72% (compared with 47% in Nelson and Canterbury) of direct labour costs on harvesting and freight, they were more efficient in labour cost/tonne (compare 7.7 person hours/tonne in Hawkes Bay with 10.6-10.8 hours/tonne in the other districts). Although labour used by individual growers has not been quoted, the figures reveal relative uniformity within districts.

3.11.2 <u>Fruit value per tree</u>

The fruit value/tree given in Table 8.17 (Appendix 1) has been calculated by applying the NZAPMB prices to the pack out counts for each grower at each harvest. Although yield/tree is the commonly used measure of difference in apple research work, a better measure of the efficiency of management practices is "return/tree". The direct costs must be deducted then, to give a net return/tree. This net return contributes to overhead costs and provides a return on investment. As the number of trees/hectare varies, the ultimate is to calculate a return net of direct costs on a per hectare basis, a so called "gross margin".

Canterbury orchards had the highest average fruit value/kg, but the lowest average fruit yield/tree. Using Canterbury orchards as a base at 100%, Hawkes Bay average return/tree was 110% and Nelson 117%.

The majority of Canterbury Gala apples were harvested in the first two picks (95%) whereas Nelson growers harvested only 70% and Hawkes Bay growers 63% in the first two picks (on a return/tree basis). Some Nelson and Hawkes Bay growers harvested for a fourth time, but this amounted to only 4% of total return. Most of this fourth harvest fruit was of poor colour destined for juicing. Future monitoring must look closely at the cost of additional picks versus additional returns from increased fruit size and value.

The distribution of fruit on the tree is important from the labour cost of harvesting point of view. Table 8.18 (Appendix 1) indicates that most of the fruit value/tree came from the first two levels in Canterbury (82%) and Nelson (65%) compared with Hawkes Bay (56%). However, these figures are based on fruit harvested from the monitored fruiting arms. Future monitoring should record the value of all fruit on the trees at each level to confirm the distribution pattern in each district and relate this to the value net of harvesting costs. Although all fruit would need to be harvested at each level and weighed in total, an assessment of size, colour, and hence fruit value, could be made from a sample of 100 fruits/level on each tree.

3.11.3 Gross Margin

Calculated Gross Margins (Returns - Direct Costs) for two cropping levels in the monitored orchards are given in Table 8.19 (Appendix 1).

As would be expected, labour costs make up most of the direct costs, 69% in Canterbury and Nelson and 72% in Hawkes Bay, based on district average yields. For the orchard with the highest yield in each district, labour costs as a percentage of direct costs are 59%, 65% and 77% for Canterbury, Nelson and Hawkes Bay respectively. It is significant that the large trees of the highest yielding Hawkes Bay orchard have increased the percentage cost of labour compared with the district average (72% to 77%) whereas the reverse applies in Canterbury (69% to 59%).

Cost of materials contributed 27% of total direct costs in Canterbury, 25% in Nelson and only 17% in Hawkes Bay. The significantly lower figure in Hawkes Bay was due to the absence of fertiliser costs.

The actual costs of disease and pest control materials was highest on average in Nelson ($1335/ha) compared with Hawkes Bay ($1087/ha) and Canterbury ($783/ha). In percentage terms Nelson growers spent 70% more on average on disease and pest control than Canterbury growers. The predominant problem was black spot, with Hawkes Bay grower No. 1 having the greatest incidence due to the dense nature of his trees.

Fertiliser costs contributed 36% of total average direct costs in Canterbury, 42%, in Nelson and 0% in Hawkes Bay. Herbicides represented 6-10% of average direct costs depending on the chemicals used and the number of applications. Machinery costs contributed 7-9% of total average direct costs.

Chemical thinning costs, mainly in Hawkes Bay and Nelson represented only 1.5%-3.5% of total average direct costs, although it is significant that yields on average were higher in orchards where chemical thinning was used.

Overall, Nelson growers had the highest total direct costs due to higher labour and material inputs.

Gross income has been calculated by multiplying the average fruit value/tree by the number of trees/hectare. Gross incomes were 12%-19% higher in Nelson and Hawkes Bay for the best orchards compared with the best Canterbury orchard. The higher yield on average, in Hawkes Bay orchards, was the major factor contributing to the 12c/kg figure for direct costs compared with 15c/kg in Nelson and Canterbury. The best yielding orchard of all 15 monitored had a direct cost/kg of only 11c.

Combining all return and direct cost figures produces an average gross margin figure of $13,679 for Hawkes Bay compared with $12,797 for Nelson and $12,055 for Canterbury. To some extent the gross margin figures are questionable due to slight tree age variations, but the differences between districts still apply if orchards of the same age are compared. Nevertheless, it will be necessary to continue the recordings for a further two to three years before the financial pattern can be firmly established. The factors contributing to the variations are analysed in the next section.

3.12 The Apple Tree System

In the introduction to this paper, the apple tree was recognised as a system containing complex interacting factors influencing its performance (Figure 1). Other authors have discussed this concept including Tukey (1970), Carlsson and Johansson (1972), Carlsson, et al (1979), Winter (1979), Blake (1982), Brooks (1985), Eiseman (1985) and Thiele (1986).

As a result of one year's work on the apple tree system, it has become evident that there are at least five integrating groups or sub systems: environmental, biological, technological, cultural, and economic. The approach used in this work appears complex, but so is the tree system.

It is tempting to quantify and classify the sub systems in terms of contribution to the end result. It is unrealistic to do so at this stage, but it can be said that the first four are all contributing to the end result. The common denominator of economics quantifies the interacting factors into growers' return/tree or/hectare. While yield/tree or/hectare may have been an acceptable measure in scientific research, differences cannot be claimed realistically without incorporating the economic sub system.

The apple tree performance has been expressed as fruit value in $/tree. The following contributing factors have been considered:

1. Environmental

   a. District
   b. Number of growing degree days (GDD).
   c. Percentage of incoming light (only in Hawkes Bay).
   d. Soil type

2. Biological

   a. Tree height
   b. Number of terminal buds
   c. Percentage of buds flowering
   d. Fruit set
   e. Number of fruit/tree
   f. Fruit weight
   g Yield/tree
   h. Crop loading index (fruit number and kg/cm^2 of butt cross sectional area).
   i. Fruit size distribution

3. Technological

   a. Tree training
   b. Number of trees/ha (spacing)
   c. Irrigation method
   d. Spray applications
   e. Thinning method
   f. Percentage of fruit harvested at each pick
   g. Labour usage

4. Cultural

   a. Chemicals used (weed, disease and pest control, thinning)
   b. Fertilisers
   c. Thinning targets
   d. Number of picks
   e. Pruning

Twelve factors have been analysed by linear multiple regression to determine the comparative contribution of these factors towards the fruit value/tree (Table 7).

Some of the factors highly correlated with each other have been discussed previously; namely yield/tree, number of fruit/tree, number of fruit/cm^2 of butt cross sectional area, and the weight of fruit/cm^2 of butt cross sectional area.

As could be expected, the highest correlation occurs with yield and fruit number in influencing return/tree (Figures 8.13 and 8.14 Appendix 3). These two factors are also positively correlated with crop loading/butt cross sectional area.

The number of degree days in Canterbury shows a positive correlation with fruit value/tree because of the higher fruit value/kg.

The correlation coefficients for number of trees/hectare and number of picks during harvesting indicate correlation with

TABLE 7: Correlation coefficients for the main factors affecting fruit value/tree

No.	Factors	Canterbury	Nelson	Hawkes Bay
1.	Yield kg/tree	0.958	0.841	0.912
2.	Number of fruit/tree	0.854	0.695	0.831
3.	Crop load - kg/butt x.s.a.	0.692	0.542	-
4.	Growing Degree Days	0.666	-	-
5.	Crop load - no fruit/butt x.s.a.	0.661	-	-
6.	Number of trees/ha	0.590	-	-
7.	Number of picks	0.564	-	-
8.	Initial fruit set (%)	0.548	0.605	0.619
9.	Number of terminal buds on level I	0.536	0.688	-
10.	Tree height (m)	-	0.513	-
11.	% of fruit harvested during first 2 picks	-	-	-0.737
12.	Labour input/ha	-	-	0.580
	R2 (all factors)	99.2%	94.3%	94.7%

fruit value/tree, but only in Canterbury orchards. The initial fruit set coefficient also indicates a possible correlation with fruit value/tree (Figure 8.15 Appendix 3).

The percentage of fruit picked during the first two picks is negatively corrrelated with fruit value/tree for Hawkes Bay orchards (Figure 8.16 Appendix 3). The R^2 figures in Table 7 indicate that the factors listed above explained 99.2% of the differences in fruit value/tree in Canterbury, 94.3% in Nelson, and 94.7% in Hawkes Bay orchards.

There were only three factors, yield/tree, number of fruit/tree, and initial fruit set, significantly correlated with fruit value/tree in all three districts. Correlation was indicated only in one or two districts in the case of the other factors.

It is not feasible after one season's records to explain with confidence the reasons for some factors showing a correlation in one district and not in another. The one year variation in tree ages between some properties could influence the results until all trees in the 15 orchards reach maturity. The next season's recordings could solve some of these problems. The differences in orchard management practices must also be significant. To identify the best methods of growing Gala apples on each property in each district is the ultimate objective in this systems approach.

4. Summary

An analysis of the interacting factors involved in the apple tree system has shown the following:

1. A comparison of districts and growers shows environmental, biological, technological, cultural and economical differences between Canterbury, Nelson, and Hawkes Bay orchards.

   Differences have occurred in terms of:

   a. Management (spacing, tree training, pruning, thinning, spraying).

   b. Tree growth and development (size, vigour, number of terminal buds, buds flowering, fruit set).

   c. Cropping (yields, fruit size and quality, crop loading and fruit size).

   d. Economics (fruit value, returns/tree and/hectare, direct material, labour and machinery inputs, gross margins).

2. There have been differences between the three tree levels.

   a. Growth of one year old wood.
   b. Terminal buds and percentage of flowering buds.
   c. Fruit set
   d. Light interception
   e. Fruit value

3. The reasons for the differences observed could be due to district variation.

   a. Climatic conditions (rainfall, growing degree days) and soil type.

   b. Grower's management practices and experience.

4. Biological relationships have been identified.

   a. A linear correlation between total arms cross sectional area and butt cross sectional area.

   b. A significant positive relationship between butt cross sectional area and yield.

   c. A highly significant correlation between yield, number of fruit/tree and crop loading/butt x.s.a.

   d. A significant negative correlation between fruit weight and crop loading/butt x.s.a.

5. Economic relationships have been established.

   a. Fruit value/tree was highly correlated with yield, number of fruit/tree and crop loading/butt x.s.a.

   b. Total fruit value/tree was affected by initial fruit set.

   c. Number of trees/ha, tree height, number of picks, percentage of fruit picked in the first two picks, and labour input affected fruit value/tree in individual districts.

6. With the dynamic nature of the fruit tree system, the preliminary relationships and differences established from one season's work, will have to be further tested and verified.

   The objective of future recording will be to formulate a computerised model of a Gala apple tree in an orchard context. The positive results of this should be:

   a. Improved management practices leading to increased returns.

b. Implementation of cultural practices based on proven biological and economic relationships rather than based on chance.

c. Development of a predictive model to facilitate harvesting and post harvest planning.

7. The Gala apple tree system is only part of a larger orchard system incorporating other varieties and training systems. Further extension of the systems diagram would incorporate the overall pip fruit industry.

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It is normal for joint authors to acknowledge jointly. I do this without constraint. A systems study of the apple tree could not be conducted without a "system" of personnel involved in the study.

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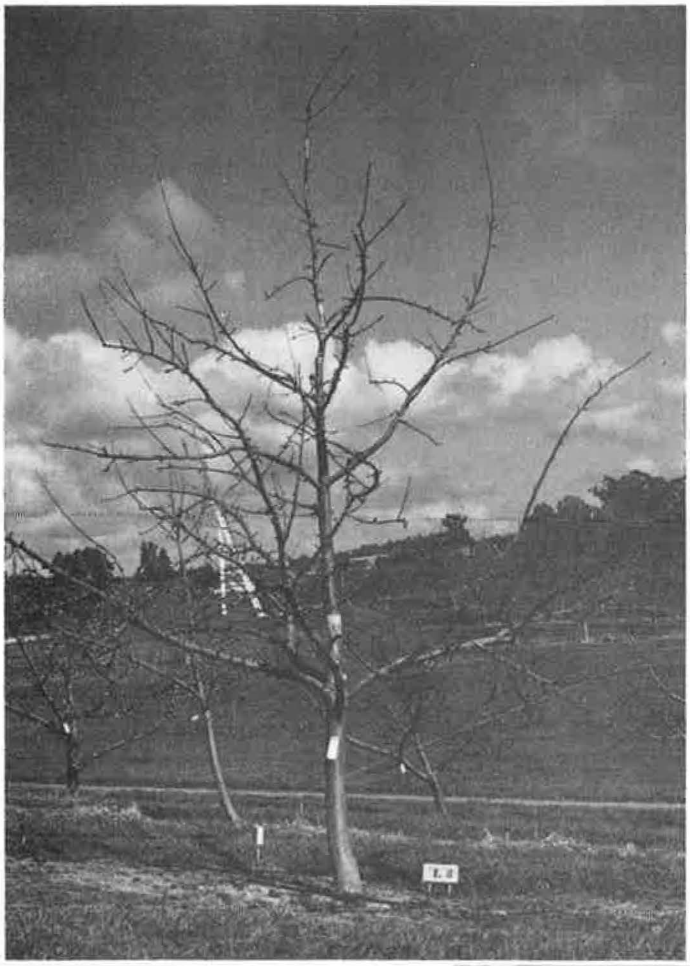
I gratefully acknowledge Piotr's contribution to horticultural research in New Zealand and the benefit personally I have received from working with him.

7. Apple Tree Development

A photographic record selected from the 15 orchards, to demonstrate the stages of development and to indicate key differences in tree shape, size, growth and cropping.

Central leader shaped tree in DSIR orchard, Havelock North, dormant stage, 18 August 1986. Average tree height - 4.47 m. Butt circumference - 30.1 cm.

Modified Axis shaped tree in Mr R Mill's orchard, Hastings; dormant, 18 August 1986. Average tree height - 5.10 m. Butt circumference - 40.9 cm.



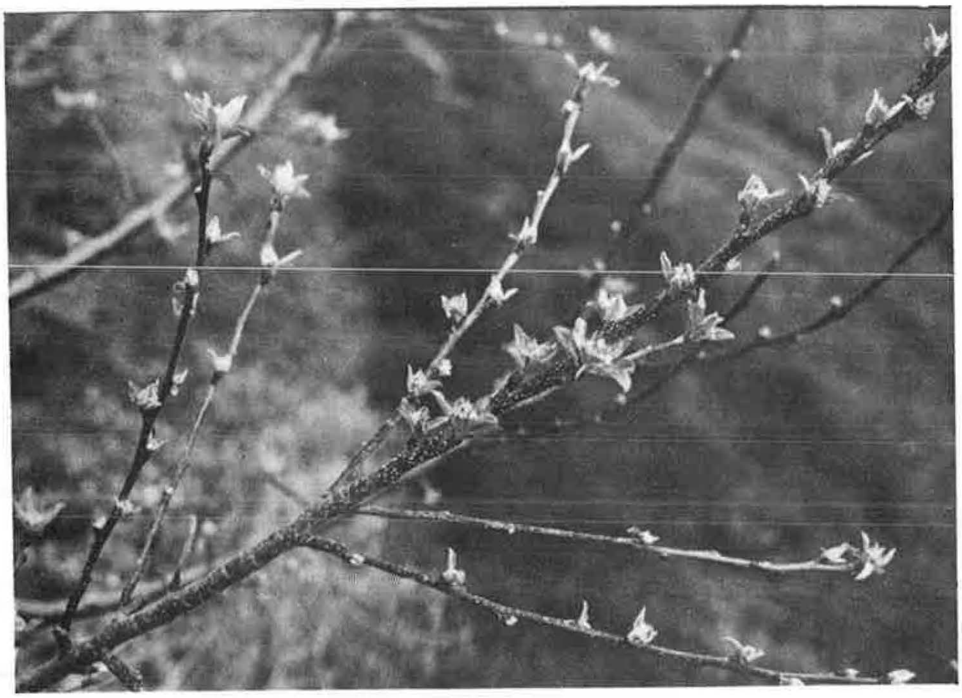
Central leader shaped tree from DSIR orchard, Appleby, Richmond, bud burst stage, 25 September 1986. Marked tree levels.
Average tree height - 4.70 m.
Butt circumference - 29.0 cm.
Average number of terminal buds per 1 cm^2 of arms cross sectional area from levels I, II and III, was: 10.9, 9.7 and 6.7 respectively.

Modified Axis shaped tree in Mr R Heasley's orchard, Belfast, Christchurch; pink stage, 15 October 1986.
Average tree height - 5.02 m.
Butt circumference - 33.7 cm.
Average flower set - 22.4% from three levels.

Central leader shaped tree from Mrs A Malcolm's orchard, Belfast, Christchurch; pink, 15 October 1986. Average tree height - 3.06 m. Butt circumference - 26.7 cm.

Central leader shaped tree in Mr W Mottram's orchard, Prebbleton, Canterbury; pink stage, 15 October 1986. Average tree height - 3.82 m. Butt circumference - 31.5 m. Average flower set - 29.5% from three levels.

Terminal buds on monitored limb in HRA, Lincoln College, 3 October 1986. Average number of terminal buds - 7.1 per 1 cm^2 of arm's x sectional area from three levels of the tree.



Bud break, South Canterbury, St Andrews orchard. Average number of terminal buds - 4.5 per 1 cm^2 of arms x sectional area from three levels.

Royal Gala blossom on one year old wood in Mr B Glasgow's orchard, 20 October 1986. Average number of flower clusters was 14.3 from three levels of the tree. Average flower set 23.2%.

Pink stage on one year old and older wood of Royal Gala in Mrs A Malcolm's orchard, Belfast, Christchurch, 15 October 1986. Average 5.9 terminal buds per 1 cm^2 of arm's x sectional area.

Royal Gala blossom in
Mr M Hoddy's orchard,
Richmond, Nelson,
23 October 1986.
Average flower set
- 40.6%.

Taking light
measurements in
Mr R Mills' orchard,
Hastings, 28 January
1987 (using Solar
Monitor Ll-1776).
Average % of
incoming light on I,
II III levels of the
tree were 12.8%,
16.5% and 50%
respectively.

Light penetration in Mr Glasgow's orchard, Hastings. Average 3.5%, 10.6% and 43.7% from I, II, III levels of the tree respectively.

Good light penetration in Mr T Waites' orchard, Havelock North. Average 19.9%, 29.8% and 43.1% from I, II, III levels respectively.

Regal Gala cropping in Mr Fulford's orchard, Hastings, 29 January 1987. Average fruit set - 4.9%, 7.5% and 11.9% on I, II, III levels respectively. Average fruit size distribution: 26.2%, 17.6% and 56.2% of fruit below 60 mm, 60-65 mm and 65-85 mm respectively. Average fruit weight - 162.4 g.

Royal Gala in Mr Waites' orchard, Havelock North, before first pick, 25 February 1987. Average fruit set 44.1%, 34.8% and 64.8% on I, II, III levels respectively. Average fruit size - 98.8% fruit of size 65-85 mm, and 1.2% over 85 mm. Average fruit weight - 192.7 g.

Appendix 1: **Tables of Results** **Page**

TABLE 8.1: **The basic characteristics of monitored trees (an average from five trees in each district)**

Orchard Code	Tree		Butt			Growth		Annual Previous Growth Ratio	Total Circumference of Arms on the Tree Arising from the Leader (cm)
	Height (m)	Width (m)	Height (cm)	Circumference (cm) August 1986	(cm) March 1987	Annual (cm) 1986	Previous (cm) 1985		
C/I	4.00	2.60	59.4	23.1	27.1	67.1	42.4	1.58	122.2
II	3.06	2.28	52.2	22.9	26.7	73.0	62.2	1.17	150.4
III	3.82	2.66	70.8	29.0	31.5	54.0	52.6	1.03	143.1
IV	3.03	1.72	60.0	20.1	23.2	74.4	67.2	1.16	103.6
V	5.02	1.91	69.2	28.5	33.7	86.2	78.2	1.10	211.2
Mean	3.79	2.23	62.3	24.7	28.4	70.9	60.5	1.21	146.1
N/I	4.38	2.96	79.2	27.0	29.1	55.4	45.2	1.23	156.9
II	4.70	2.99	88.0	27.4	29.5	77.2	73.0	1.06	203.0
III	3.93	2.63	84.0	26.4	29.0	50.6	66.0	0.77	152.1
IV	4.47	2.84	77.8	25.7	27.8	64.6	86.2	0.75	175.9
V	3.67	1.94	55.0	21.9	23.9	58.4	76.8	0.76	163.8
Mean	4.23	2.67	76.8	25.7	27.9	61.2	69.4	0.91	170.3
HB/I	5.15	2.20	64.8	27.8	30.2	87.8	69.2	1.27	185.5
II	3.81	2.55	62.8	21.3	23.7	74.0	76.2	0.97	164.6
III	4.47	2.65	85.8	28.2	30.1	76.8	75.4	1.02	169.4
IV	5.10	3.30	86.4	37.7	40.9	107.8	104.8	1.03	250.8
V	4.52	2.89	84.6	25.5	27.7	54.8	78.4	0.70	207.0
Mean	4.61	2.72	76.9	28.1	30.5	80.2	80.8	1.00	195.5

TABLE 8.2: Average circumference of the monitored arms adjacent to the leader (cm)

Orchard Code	Level I (<1.2m)*		Level II (1.2-2.6m)*		Level III (>2.6m)*	
	August 1986	March 1987	August 1986	March 1987	August 1986	March 1987
C/I	7.82	9.01	7.50	8.76	7.60	10.04
II	7.13	8.70	6.63	8.45	3.08	6.51
III	7.76	8.79	7.54	9.39	7.26	9.76
IV	5.65	6.78	5.72	8.26	3.52	5.71
V	7.41	8.48	7.35	8.35	7.28	9.01
Mean	7.15	8.35	6.95	8.64	5.75	8.21
N/I	7.03	8.26	6.66	8.04	6.75	8.04
II	7.16	8.13	6.59	7.76	6.78	8.08
III	7.32	8.35	7.35	8.83	7.34	8.80
IV	7.51	8.41	7.29	7.94	7.41	8.26
V	6.84	7.54	6.47	7.75	6.44	8.17
Mean	7.17	8.14	6.87	8.06	6.94	8.27
HB/I	7.88	8.88	7.75	8.48	7.54	9.48
II	6.28	7.48	6.25	7.40	6.22	8.10
III	6.75	8.00	6.94	8.16	6.88	9.01
IV	8.14	9.26	7.82	9.07	7.69	8.38
V	7.85	9.20	7.66	9.26	7.69	9.54
Mean	7.38	8.56	7.28	8.47	7.20	8.90

* Height from ground level.

TABLE 8.3: **Number of terminal buds on monitored arms from three levels of the tree (an average from five trees in each orchard and district).**

Orchard Code	Level I (<1.2 m)		Level II (1.2-2.6 m)		Level III (>2.6 m)	
	Number of terminal buds	Buds per 1 cm^2 of arm cross-sectional area	Number of terminal buds	Buds per 1 cm^2 of arm cross-sectional area	Number of terminal buds	Buds per 1 cm^2 of arm cross-sectional area
C/I	57.0	11.6	27.6	5.0	17.0	3.6
II	45.8	11.5	16.4	4.9	1.0	1.3
III	50.6	10.1	41.8	9.1	19.0	4.5
IV	18.4	7.5	12.0	4.8	1.2	1.2
V	42.4	9.5	23.8	6.0	31.0	7.3
Mean	**42.8**	**10.0**	**24.3**	**6.2**	**13.8**	**3.6**
N/I	61.6	15.8	20.2	6.0	16.0	4.4
II	54.0	13.1	37.6	10.6	10.2	2.8
III	45.4	10.9	43.0	9.7	29.4	6.7
IV	58.8	13.1	37.4	8.8	16.0	3.6
V	32.4	8.7	18.0	5.2	12.6	3.5
Mean	**50.4**	**12.3**	**31.2**	**8.1**	**16.8**	**4.2**
HB/I	40.8	8.3	45.8	9.5	21.0	4.1
II	29.8	9.0	27.0	8.9	26.2	8.8
III	52.4	14.5	28.0	7.9	21.0	5.7
IV	38.6	7.1	32.2	6.5	27.0	5.6
V	55.6	11.3	46.4	9.8	39.0	8.2
Mean	**43.4**	**10.0**	**35.9**	**8.5**	**26.8**	**6.5**

TABLE 8.4: **One year old laterals on monitored arms from different levels of the tree (an average from five trees in each orchard and district)**

	Level I			Level II			Level III		
Orchard Code	Total length of one year laterals [cm]	Number of buds on laterals	Buds per 10 cm of lateral	Total length of one year old laterals [cm]	Number of buds on laterals	Buds per 10 cm of lateral	Total length of one year old laterals [cm]	Number of buds on laterals	Buds per 10 cm of lateral
C/I	414.2	141.6	3.4	279.2	94.4	3.4	306.8	95.6	3.2
II	462.6	156.6	3.4	233.6	75.2	3.2	46.4	17.0	3.7
III	297.0	103.0	3.5	155.4	54.6	3.5	249.4	86.4	3.4
IV	245.8	83.8	3.6	189.2	59.6	3.1	42.4	19.2	4.5
V	70.6	20.0	2.9	112.0	33.2	2.3	146.4	46.4	3.2
Mean	298.0	101.0	3.4	193.9	63.4	3.1	158.3	52.9	3.6
N/I	328.6	72.6	2.2	192.8	46.4	2.5	226.0	47.4	2.1
II	513.8	105.8	2.1	367.4	81.4	2.2	213.4	48.4	2.3
III	142.2	43.6	3.0	162.0	46.6	2.9	119.4	35.0	2.4
IV	392.2	80.8	2.1	186.6	44.6	2.4	331.8	76.6	2.4
V	208.0	48.8	2.4	157.4	41.0	2.6	265.6	71.8	2.8
Mean	317.0	70.3	2.4	213.2	52.0	2.5	231.2	55.8	2.4
HB/I	87.0	19.4	2.5	217.8	55.6	2.6	411.6	103.8	2.5
II	197.0	53.2	2.7	137.0	35.4	2.6	189.2	50.8	2.8
III	99.0	26.0	2.7	159.6	45.8	2.9	215.8	59.0	2.7
IV	108.0	32.8	3.3	177.8	51.4	2.8	273.4	72.8	2.7
V	98.4	28.2	2.7	170.2	53.4	3.1	192.2	68.0	3.5
Mean	117.9	31.9	2.8	172.5	48.3	2.8	256.4	70.9	2.8

TABLE 8.5: Terminal buds versus fruit quality*

District	Tree Level	Terminal buds/1 cm^2 of arms x sectional area	Fruit per 1 cm^2 of arms x sectional area	
			Export size (65-85 cm)	Total
C	I	10.0	4.7	5.9
	II	6.2	3.3	7.5
	III	3.6	2.1	3.4
	Mean	6.6	3.4	5.6
N	I	12.3	5.9	10.7
	II	8.1	4.0	7.4
	III	4.2	2.8	5.6
	Mean	8.2	4.2	7.9
HB	I	10.0	3.2	2.8
	II	8.5	2.9	6.0
	III	6.5	4.9	8.0
	Mean	8.3	3.7	5.6

*Averages from five trees and orchards in each district.

TABLE 8.6: **Number of flower clusters and flowers on monitored arms from different levels of the tree (an average for orchards and districts)**

Orchard Code	Level I			Level II			Level III		
	Number of flower clusters	Average number of single flowers cluster	Total number of flowers/cm^2 of arms x.s. area	Number of flower clusters	Average number of single flowers cluster	Total number of flowers/cm^2 of arms x.s. area	Number of flower clusters	Average number of single flowers cluster	Total number of flowers/cm^2 of arms x.s. area
C/I	38.2	5.4	42.3	38.4	5.5	47.1	20.2	5.4	23.5
II	121.4	5.6	166.4	56.0	5.5	85.8	16.4	5.5	119.6
III	44.8	5.7	52.4	24.0	5.6	29.5	30.2	5.6	39.8
IV	54.4	5.7	116.7	36.8	5.6	78.5	16.0	5.4	87.3
V	20.8	5.3	24.5	9.4	5.3	11.5	10.2	5.8	13.8
Mean	55.9	5.5	80.5	32.9	5.5	50.5	18.6	5.5	56.8
N/I	97.2	5.4	131.9	48.4	5.3	71.8	54.6	5.2	76.2
II	69.4	5.5	91.7	73.0	5.4	112.1	37.4	5.3	53.3
III	20.6	5.2	25.1	15.4	5.2	18.7	6.6	5.4	8.2
IV	81.8	5.2	94.2	52.0	5.2	63.1	59.0	5.2	69.0
V	33.0	4.8	42.5	27.0	5.1	41.2	26.6	5.2	40.9
Mean	62.4	5.2	77.1	43.2	5.2	61.4	36.8	5.3	49.5
HB/I	12.6	5.1	13.0	24.6	5.4	27.5	31.4	5.4	35.6
II	52.0	5.2	87.1	54.8	4.9	84.7	33.8	4.8	51.5
III	41.6	5.2	59.1	47.4	5.4	63.7	21.8	5.2	29.0
IV	28.0	5.2	26.9	21.6	5.1	22.4	41.2	5.4	46.6
V	10.2	5.2	10.7	10.4	5.0	56.1	6.2	5.2	6.8
Mean	28.9	5.2	39.4	31.8	5.2	50.9	26.9	5.2	33.9

TABLE 8.7: **Flowering buds as a percentage of total buds**

Orchard Code	Levels of the tree		
	I	II	III
C/I	19.9	30.2	16.5
II	60.2	62.5	89.3
III	32.5	25.4	30.5
IV	54.0	52.4	79.4
V	33.9	19.8	13.6
Mean	40.1	38.1	45.9
N/I	71.4	74.4	79.4
II	42.3	58.9	64.1
III	25.0	19.5	13.7
IV	58.7	63.6	62.1
V	44.2	46.7	30.8
Mean	48.3	52.6	50.0
HB/I	20.5	23.1	25.9
II	63.3	82.4	45.3
III	51.7	46.3	28.5
IV	41.4	26.2	41.2
V	14.3	13.2	7.4
Mean	38.2	38.2	29.7

TABLE 8.8: Number of flower clusters versus fruit quality

Districts	Tree Level	Number of Flower Clusters	Fruit Size Distribution in %			Total Number of Fruit Harvested	Fruit Harvested per 100 Flower Clusters
			65-85 mm	60-65 m	Reject		
C	I	55.9	76.6	16.6	6.8	37.4	66.9
	II	32.9	79.4	16.3	4.3	26.4	80.2
	III	18.6	79.4	14.8	5.8	17.2	92.5
	Mean	**35.8**	**78.5**	**15.9**	**5.6**	**27.0**	**79.9**
N	I	62.4	83.4	12.4	4.2	39.2	62.8
	II	43.2	75.7	17.2	7.1	31.8	73.6
	III	36.8	72.5	21.2	6.3	29.2	79.3
	Mean	**47.5**	**77.2**	**16.9**	**5.9**	**33.4**	**71.9**
HB	I	28.9	84.2	10.9	4.9	23.5	81.3
	II	31.8	78.0	8.3	13.7	25.8	81.1
	III	26.9	79.7	15.6	4.7	42.5	158.0
	Mean	**29.2**	**80.6**	**11.6**	**7.8**	**30.6**	**106.0**

TABLE 8.9: Fruit set, size distribution and fruit weight

District	Tree Level	Fruit Set as a percentage of individual flowers		Fruit Size Distribution %			Average Fruit Weights (g)
		Initial	Final	65-85 mm	60-65 mm	Reject	
C	I	49.9	15.8	76.6	16.6	6.8	142.1
	II	51.4	18.7	79.4	16.3	4.3	147.5
	III	49.0	17.5	79.4	14.8	5.8	149.4
	Mean	50.1	17.3	78.5	15.9	5.6	146.3
N	I	35.3	17.0	83.4	12.4	4.2	146.8
	II	38.6	20.1	75.7	17.2	7.1	142.8
	III	47.0	25.4	72.5	21.2	6.3	141.1
	Mean	40.3	20.8	77.2	16.9	5.9	143.6
HB	I	41.5	24.1	84.2	10.9	4.9	155.9
	II	45.4	29.6	78.0	8.3	13.7	156.9
	III	52.7	33.6	79.7	15.6	4.7	160.2
	Mean	46.5	29.1	80.6	11.6	7.8	157.7

TABLE 8.10: Thinning in monitored orchards

Orchard Code	Number of fruit before thinning/1 cm^2 of arms x sectional area*			% of fruit removed during thinning		
	Level			Level		
	I	II	III	I	II	III
C/I	23.9	28.6	13.5	54.4	53.4	61.4
II**	107.7	70.0	89.6	90.0	86.1	98.2
III	21.0	13.9	12.8	46.4	43.3	42.9
IV	58.9	17.5	25.6	NT	NT	NT
V	8.9	5.2	5.5	30.0	31.9	26.5
Mean	43.9	27.0	29.4	44.2	42.9	45.8
N/I**	72.8	53.1	51.7	75.0	78.9	77.1
II	19.0	25.4	12.3	29.5	35.7	32.4
III	13.0	9.1	6.0	NT	NT	NT
IV**	25.6	15.6	14.4	54.3	50.7	45.9
V	7.6	5.4	7.7	7.8	13.3	20.1
Mean	27.6	21.7	18.4	33.3	35.7	35.1
HB/I	5.5	10.1	10.9	NT	NT	NT
II**	4.1	6.1	5.0	94.3	92.5	88.1
III**	26.3	23.0	51.5	54.8	60.8	51.0
IV**	18.1	15.7	28.1	50.0	50.6	50.3
V	4.2	4.5	4.6	20.7	18.4	27.6
Mean	11.6	11.9	20.0	44.0	44.5	43.4

NT - No hand thinning in these orchards.

* In the case of chemical thinning this is the number of fruit remaining after the effect of the chemical application.

**Growers chemically thinned.

TABLE 8.11: Average % of incoming light versus fruit size and weight in Hawkes Bay orchards.

Grower	Tree Level	% of Incoming Light	Fruit Size Distribution in %			Average Fruit Weight (g)
			60-65 mm	65-85 mm	Rejects	
I	I	3.5	23.3	63.7	13.0	133.1
	II	10.6	10.3	42.6	47.1	126.5
	III	43.7	27.3	62.3	10.4	126.3
II	I	13.6 }				
	II	29.9 }	17.6*	56.2*	26.2*	162.4*
	III	54.6 }				
III	I	16.2	8.4	89.3	2.3	149.9
	II	36.5	8.5	83.8	7.6	148.1
	III	54.0	15.4	80.0	4.6	139.6
IV	I	12.8	11.8	83.8	4.4	139.7
	II	16.5	14.5	85.5	0.0	153.1
	III	50.0	15.5	80.5	4.0	142.0
V	I	19.9	0	100.0	0	190.6
	II	29.8	0	100.0	0	189.2
	III	43.1	0	100.0	0	199.7

* Average for the whole block because the grower failed to keep detailed records during harvesting.

TABLE 8.12: **Yields***

Code	Average Yield kg/tree	Number of Trees /ha	Average Yield t/ha
C/I	100	371	47.0
II	84	740	62.0
III	92	625	57.5
IV	48	740	35.5
V	59	634	37.5
Mean	**76.7**	**662**	**48.0**
N/I	112	666	74.5
II	115.6	571	34.0
III	92	454	42.0
IV	107	740	79.0
V	61	800	49.0
Mean	**97.4**	**646**	**56.0**
HB/I	77	888	68.0
II	70	571	40.0
III	94	740	69.5
IV	167	565	86.5
V	67	625	42.0
Mean	**95.0**	**678**	**61.0**

***Averages from five trees for each grower.**

TABLE 8.13: Fruit weight and size distribution (%)

District	Grower	Average Fruit Weight (g)	Fruit Size Distribution % 60-65 mm	65-75 mm	75-85 mm	Rejects
C	I	140.1	13.1	69.3	11.3	6.3
	II	156.2	9.0	73.1	12.5	5.4
	III	128.5	17.0	74.2	4.0	4.8
	IV	137.8	28.8	57.8	3.9	9.5
	V	151.8	13.4	73.5	9.4	3.7
	Mean	**142.9**	**16.3**	**69.6**	**8.2**	**5.9**
N	I	142.8	16.0	66.8	13.0	4.2
	II	132.8	19.7	65.8	2.9	11.6
	III	151.7	7.1	66.0	25.0	1.9
	IV	133.9	22.8	69.2	5.0	11.0
	V	145.2	17.6	74.1	7.5	0.8
	Mean	**141.3**	**16.6**	**66.8**	**10.7**	**5.9**
HB	I	127.6	20.5	47.7	7.8	24.0
	II	162.4	17.6	40.2	16.0	26.2
	III	144.2	11.9	68.8	14.7	4.6
	IV	143.9	14.2	74.2	8.5	3.1
	V	192.7	0.0	38.1	61.9	0.2
	Mean	**154.2**	**12.8**	**53.8**	**21.8**	**11.6**

TABLE 8.14: Fruit weight and size distribution according to tree levels*

District	Grower	Average Fruit Weight (g)			Fruit Size Distribution in % from tree levels											
					60-65 mm			65-75 mm			75-85 mm			Rejects		
		Level I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
C	I	135.0	137.3	151.8	12.1	18.4	6.4	73.0	67.6	67.3	7.9	10.4	16.6	7.0	3.6	9.7
	II	153.5	160.5	150.0	8.1	10.5	0.0	75.3	69.1	100.0	8.7	18.6	0.0	7.9	1.9	0.0
	III	126.9	137.1	123.4	20.0	7.1	22.3	75.5	86.3	60.8	1.9	2.1	8.7	2.6	4.5	8.2
	IV	114.4	139.0	142.5	25.9	33.7	34.4	57.4	61.3	46.7	5.3	0.0	8,0	11.4	5.0	10.9
	V	143.5	155.6	158.6	17.0	11.8	10.8	71.3	65.5	81.7	6.6	16.1	7.5	5.1	6.6	0.0
	Mean	**134.7**	**145.9**	**145.3**	**16.6**	**16.3**	**14.8**	**70.5**	**70.0**	**71.3**	**6.1**	**9.4**	**8.2**	**6.8**	**4.3**	**5.7**
N	I	148.4	139.6	135.4	9.2	20.2	25.4	73.3	58.7	63.3	15.1	13.4	7.9	2.4	7.7	3.4
	II	135.7	129.2	133.3	16.2	24.7	18.2	72.0	57.2	68.2	2.6	3.9	1.5	9.2	14.2	12.1
	III	149.5	148.2	161.7	6.4	7.2	8.4	64.7	67.3	66.5	26.2	23.6	25.1	2.7	1.9	0.0
	IV	144.2	139.9	123.2	16.1	19.7	30.5	71.1	64.9	50.7	6.9	5.8	2.9	5.9	9.6	15.9
	V	149.3	143.3	142.7	14.0	14.2	23.5	77.8	80.0	66.4	7.5	3.7	10.1	0.7	2.1	0.0
	Mean	**145.4**	**140.0**	**139.3**	**12.4**	**17.2**	**21.2**	**71.8**	**65.6**	**63.0**	**11.7**	**10.1**	**9.5**	**4.1**	**7.1**	**6.3**
HB	I	133.1	126.5	126.3	23.3	10.3	27.3	53.6	37.5	53.2	10.1	5.1	9.1	13.0	47.1	10.4
	II	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	III	149.9	148.1	139.6	8.4	8.5	15.4	68.5	67.1	69.7	20.8	16.8	10.3	2.3	7.6	4.6
	IV	139.7	153.1	142.0	11.8	14.5	15.5	82.7	65.3	73.8	1.1	20.2	6.7	4.4	0.0	4.0
	V	190.6	189.2	199.7	0.0	0.0	0.0	36.4	42.8	33.8	63.6	57.2	66.2	0.0	0.0	0.0
	Mean	**153.3**	**154.2**	**151.9**	**10.9**	**8.3**	**14.6**	**60.3**	**53.2**	**57.6**	**23.9**	**24.8**	**23.1**	**4.9**	**13.7**	**4.7**

*Averages from arms located on different levels of the tree.
NA - Not Available; grower failed to keep recordings.

TABLE 8.15: Yields, fruit weight and crop loading in monitored orchards

Orchard Code	Butt Cross Sectional Area (cm)*	Yield** (kg/tree)	No of fruit per cm^2 butt Kg/1cm^2 x.s.a.	kg/1 cm^2 butt x.s.a. butt x.s.a.	Average fruit weight (g)
C/I	42.77	100.0	16.74	2.36	140.1
II	42.03	84.0	13.06	2.01	156.2
III	67.44	92.0	10.79	1.39	128.5
IV	32.68	48.0	10.47	1.48	137.8
V	65.20	59.0	6.25	0.95	151.8
Mean	50.02	76.7	11.46	1.64	142.9
N/I	58.50	112.0	13.34	1.92	142.8
II	60.20	115.6	14.63	1.93	132.8
III	56.10	92.0	10.51	1.59	151.7
IV	50.03	107.0	15.86	2.13	133.9
V	38.54	61.0	11.01	1.59	145.2
Mean	52.67	97.4	13.07	1.83	141.3
HB/I	61.84	77.0	9.50	1.24	127.6
II	36.34	70.0	11.86	1.92	162.4
III	63.67	94.0	10.00	1.47	144.2
IV	113.82	167.0	10.36	1.49	143.9
V	52.02	67.0	6.51	1.27	192.7
Mean	65.54	95.0	9.65	1.48	154.2

* August 1986, average of five trees in each orchard.

** March 1987, average of five trees in each orchard.

TABLE 8.16: Average labour inputs (person hours/ha)*

Specification	Canterbury	Nelson	Hawkes Bay
Average number of trees/ha	662	646	678
Pruning	52.0	68.0	73.0
Thinning[1]	164.0	179.0	1.5
Pest and Disease Control	23.0	25.0	23.0
Weed Control	3.5	3.0	9.5[4]
Mowing	8.0	10.0	9.0
Fertiliser application	2.5	2.5	-
Harvesting and freight[2]	240.0	285.0	335.0
Others[3]	17.0	30.5	17.0
Total Direct Labour Input	510.0	603.0	468.0
Average Yield tonnes/ha	48.0	56.0	61.0
Person-hours/tonne	10.6	10.8	7.7

* Estimated figures based on grower interviews, recording cards, average from five orchards in each district.

1. In Canterbury and Nelson mainly hand thinning, in Hawkes Bay - chemical thinning.

2. In Canterbury from 1-3 picks, Nelson from 2-4, Hawkes Bay from 3-4.

3. Includes: tree training, irrigation, tree replacement, etc.

4. Includes hand weeding.

TABLE 8.17: **Average fruit value in $/tree for each pick***

Orchard Code	Fruit Value/tree ($/pick) 1	2	3	4	Total fruit Value/tree ($)
C/I	22.01	18.29	-	-	40.30
II	10.20	18.12	2.57	-	38.89
III	15.27	13.46	4.38	-	33.11
IV	15.86	-	-	-	15.86
V	4.32	17.26	-	-	21.58
Mean	13.53	13.43	1.39	-	28.35
N/I	9.35	24.50	7.01	-	40.86
II	15.89	7.13	8.06	1.43	32.51
III	25.58	10.18	-	-	35.76
IV	12.18	11.51	10.90	-	34.55
V	5.01	5.50	12.07***		22.59
Mean	13.60	11.76	6.79	1.10	33.25
HB/I	8.49	12.48	3.45***		24.42
II**	6.10	10.18	4.08	-	20.36
III	13.78	11.24	10.15	-	35.17
IV	3.91	11.34	27.51	5.20	47.97
V	11.12	12.85	3.72	-	27.69
Mean	8.68	11.62	9.49	1.33	31.12

* Value of fruit counted by separate picks and fruit size distribution according to prices paid by the NZAPMB for the 1987 season.

** Based on the grower's average packout for the whole block, due to the grower failing to make detailed recordings.

***Total for both third and fourth picks.

TABLE 8.18: Average value of fruit picked from monitored arms at each level ($)

District	Tree level	Total Fruit Value from Monitored Arms ($)	Fruit Value $/cm^2 of Arms x.s.a.
C	I	9.31	1.68
	II	7.19	1.19
	III	4.77	0.64
	Mean	7.09	1.17
N	I	10.54	1.88
	II	7.65	1.45
	III	6.40	1.27
	Mean	8.19	1.53
HB	I	6.55	1.09
	II	6.41	1.06
	III	10.63	1.67
	Mean	7.86	1.27

TABLE 8.19: Calculated Gross Margin for Royal Gala ($/ha)

Specification	Canterbury		Nelson		Hawkes Bay	
	Average Yield 48t/ha	Best Yield 62t/ha	Average Yield 56t/ha	Best Yield 79t/ha	Average Yield 61t/ha	Best Yield 86t/ha
Labour Cost:						
Pruning	312.00	372.00	408.00	672.00	474.50	611.00
Thinning	984.00	6.00	1,074.00	6.00	10.00	6.50
Pest and Disease Control	138.00	162.00	150.00	84.00	150.00	149.50
Weed Control	21.00	24.00	18.00	18.00	65.00	247.00
Mowing	48.00	36.00	60.00	66.00	58.50	45.50
Fertilizing	15.00	18.00	15.00	18.00	-	-
Harvesting and Freight	2,880.00	4,340.00	3,920.00	5,530.00	4,270.00	6,020.00
Others	272.00	242.00	348.00	720.00	330.00	350.00
Total Labour Cost	4,670.00	5,200.00	5,993.00	7,114.00	5,358.00	7,429.50
Total Machinery Cost	642.00	720.00	756.00	834.00	729.00	672.00
Materials:						
Insecticides and Fungicides	782.70	1,517.20	1,335.20	1,005.90	1,087.30	1,378.00
Herbicides	162.50	146.30	177.20	87.60	202.40	94.70
Fertilizers	455.00	1,168.40	420.80	1,875.00	-	-
Others	-	108.80	-	38.40	43.90	58.60
Total Cost of Materials	1,400.20	2,940.70	1,933.20	3,006.90	1,333.60	1,531.30
Total Direct Costs	6,712.20	8,860.70	8,682.20	10,954.90	7,420.60	9,632.80
Gross Income	18,767.70	22,858.60	21,479.50	25,567.00	21,099.40	27,103.00
Direct Cost $/kg	0.15	0.14	0.15	0.13	0.12	0.11
Gross Margin	12,055.50	13,997.90	12,797.30	14,612.10	13,678.80	17,470.20

<u>Appendix 2</u>: **Cultural Details** | <u>Page</u>

TABLE 8.20: Spray Programmes : Canterbury Growers 1986/87

Growers Month	I Chemical	ml, g/100L	II Chemical	ml,g/100L	III Chemical	ml, g/100L	IV Chemical	ml, g/100L	V Chemical	ml, g/100L
September	Oil	2L	Oil }	2.5L	Oil }	2.5L	Copper }	500	Dodine	80
	Topas }	100	Copper }	500	Lindane}	100	Oxychloride}			
	Apollo }	40	Oxychloride}				(August)			
	Lorsban}	100	(August		Dodine	80	Syllit	80		
			Lindane}	100						
			Dodine }	80			Lorsban}	100		
							Syllit }	80		
			Rubigan	25						
			Rubigan	25						
October	Topas	100	Baycor }	20	Dodine }	80	Polyram }	150	Polyram }	150
	Topas	100	Polyram}	150	Polyram}	150	Bayleton}	50	Baycor }	20
			Nimrod }	50	Rubigan}	25			Bayleton}	50
	Topas }	100	Baycor }	20	Polyram}	150	Polyram }	150	Polyram }	150
	Pallinal}	100	Polyram}	150	Rubigan}	25	Bayleton}	50	Baycor }	20
			Nimrod }	50					Bayleton}	50
	Baycor }	20			Polyram }	150	Dodine }	100		
	Pallinal}	180	Baycor }	20	Bayleton}	25	Calcium N}	600	Polyram }	150
			Polyram}	150			Nitrate }		Baycor }	20
			Nimrod }	50					Bayleton}	50
			Baycor }	20					Polyram }	150
			Polyram}	150					Baycor }	20
			Nimrod }	50					Bayleton}	50
			Foliar }	100						
			Fertilon}							
November	Lorsban}	75	Nimrod }	50	Polyram }	150	Topas	100	Polyram }	150
	Topas }	200	Polyram }	150	Bayleton}	25	Topas	100	Baycor }	20
			Fertilon}	100					Bayleton}	50
			ANA	6	Polyram}	150	Polyram }	150	Polyram }	150
			Regulaid}	50	Rubigan}	25	Bayleton }	50	Polyram }	20
			Septan }	100	Kilval }	125	Lorsban }	50	Gusathion}	75
							Calcium N}	600	Plictran }	30
							Nitrate }		Calcium N}	500

TABLE 8.20: Continued: Spray Programmes : Canterbury Growers 1986/87

Growers Month	I Chemical	ml, g/100L	II Chemical	ml,g/100L	III Chemical	ml, g/100L	IV Chemical	ml, g/100L	V Chemical	ml, g/100L
November (contd..)			Nimrod }	50	Polyram}	150	Polyram }	150		
			Polyram }	150	Rubigan}	25	Bayleton }	50		
			Calcium N}	500			Captan }	100		
							Calcium N}	600		
			Captan	150						
			Nimrod }	50						
			Baycor }	20						
			Gusathion}	150						
			Calcium N}	500						
December	Dodine }	80	Lorsban }	75	Dodine }	70	Polyram }	150	Polyram }	150
	Polyram }	150	Nimrod }	50	Gusathion}	75	Pallitop }	50	Gusathion}	75
	Gusathion}	75	Dodine }	80			Topas }	100	Calcium N}	500
	Calcium N}	600	Calcium N}	500			Gusathion}	75		
	Dodine }	80	Gusathion}	150			Calcium N}	600		
	Polyram }	150	Bayleton }	25						
	Gusathion}	75	Orthocide}	400			Apollo	40		
	Pallinal }	200	Calcium N}	500						
	Calcium N}	600					Bayleton }	35		
							Captan }	100		
	Dodine }	80	Gusathion}	150			Baycor }	20		
	Polyram }	150	Bayleton }	25			Calcium N}	600		
	Gusathion}	75	Orthocide}	400						
	Pallinal }	200	Calcium N}	500			Polyram }	150		
	Calcium N}	600	Fertilon }	100			Pallitop }	50		
							Lorsban }	100		
							Calcium N}	600		

TABLE 8.20: Continued: Spray Programmes : Canterbury Growers 1986/87

Growers Month	I Chemical	ml, g/100L	II Chemical	ml,g/100L	III Chemical	ml, g/100L	IV Chemical	ml, g/100L	V Chemical	ml, g/100L
January	Polyram }	150	Calcium N}	800			Pallitop }	50	Dodine }	80
	Dodine }	80	Chloride }				Gusathion}	75	Calcium N}	500
	Calcium N}	600	Gusathion}	150			Calcium N}	600		
			Bayleton }	25					Polyram }	150
	Benlate }	50	Orthocide}	400			Topas }	100	Dodine }	80
	Gusathion}	75					Dithane }	150	Gusathion}	75
	Polyram }	150					Calcium N}	600	Calcium N}	500
	Calcium N}	600								
							Polyram }	150	Dodine }	80
							Dithane }	150	Calcium N}	500
							Lorsban }	50		
							Polyram }	150		
							Pallitop }	50		
							Calcium N}	600		
February	Polyram }	150	Bayleton }	25			Captan	100	Dodine }	80
	Benlate }	50	Calcium }	800			Bayleton }	35	Calcium N}	500
	Calcium N}	600	Chloride }				Gusathion}	75		
							Pallitop }	50		
	Benlate }	150					Syllit }	80		
	Peropal }	100					Calcium N}	600		
	Captan }	125								
	Calcium N}	600								

TABLE 8.21: **Spray Programmes : Nelson Growers 1986/87**

Growers Month	I Chemical	ml, g/100L	II Chemical	ml,g/100L	III Chemical	ml, g/100L	IV Chemical	ml, g/100L	V Chemical	ml, g/100L
September	Dodine }	80	Syllit	80	Dodine	60	Dodine	80	Melprex	80
	Apollo }	40								
			Syllit }	80			Dodine }	80	Melprex }	80
	Polyram }	450	Apollo }	40			Apollo }	40	Apollo }	50
	Pallinal}	600								
			Syllit	80						
October	Polyram }	450	Topas	100	Dodine	235	Polyram }	150	Polyram }	150
	Baycor }	80					Bayleton}	25	Baycor }	20
			Topas	100	Polyram }	450				
	Pallinal }	600			Pallitop }	200	Agrimycin	120	Polyram }	150
	Baycor }	80	Topas	100	Baycor }	20			Baycor }	20
							Polyram }	150		
	Polyram }	450	Pallinal}	600	Polyram }	450	Bayleton}	25	Pallinal }	200
	Baycor }	80	Dithane }	125	Pallitop }	200			Baycor }	20
					Baycor }	20	Polyram }	150		
	Pallinal }	600					Bayleton}	25	Polyram	150
	Solibor }	170								
	Gusathion}	100								
	Seamac }	1.5L								
November	A.N.A. }	7	Lorsbsan }	50	Polyram }	600	Gusathion }	100	Bayleton }	25
	Regulaid }	250	Dithane }	125	Pallitop}	200	Polyram }	150	Polyram }	150
							Bayleton }	25	Lorsban }	75
	Septan	120	Pallitop }	150	Gusathion}	375				
			Dithane }	125	Polyram }	600	Septan	100	Polyram }	150
	Polyram }	450			Pallitop }	200			Bayleton }	25
	Pallitop }	150	Lorsban }	50			Lorsban }	75	Lorsban }	75
	Gusathion}	100	Dithane }	125			Polyram }	150		
			Calcium C}	360			Bayleton }	25	Polyram }	150
	Polyram }	450							Gusathion}	100
	Topsin }	150							Calcium C}	360
	Lorsban }	225								

TABLE 8.21: **Continued: Spray Programmes : Nelson Growers 1986/87**

Growers Month	I Chemical	ml, g/100L	II Chemical	ml,g/100L	III Chemical	ml, g/100L	IV Chemical	ml, g/100L	V Chemical	ml, g/100L
December	Polyram	375	Dithane }	125	Captan }	500	Gusathion }	100	Captan }	100
			Topsin }	50	Pallitop }	200	Captan }	100	Bayleton }	25
	Captan }	100	Calcium C }	360	Gusathion}	375	Bayleton }	25	Lorsban }	50
	Lorsban }	225					Calcium C }	360	Calcium C}	600
			Calcium C	360	Calcium C}	360				
	Polyram	450			Citowett }	10	Lorsban }	75	Calcium C	360
			Pallitop }	150			Captan }	100		
	Polyram }	450	Dithane }	125	Gusathion}	375	Bayleton }	25	Calcium C	360
	Pallitop}	150	Calcium C }	360	Captan }	500	Calcium C }	360		
	Lorsban }	225			Pallitop }	200			Calcium C	360
			Captan	100						
	Polyram }	450			Calcium C}	360			Dithane }	150
	Calcium C}	360			Chloride }	10			Bayleton }	25
	Foliar }	300			Citowett }				Calcium C}	360
	Nitro- }									
	phoska }								Dithane }	150
									Bayleton }	25
									Gusathion}	100
									Calcium C}	360

TABLE 8.21: **Continued: Spray Programmes : Nelson Growers 1986/87**

Growers Month	I Chemical	ml, g/100L	II Chemical	ml,g/100L	III Chemical	ml, g/100L	IV Chemical	ml, g/100L	V Chemical	ml, g/100L
January	Calcium C}	360	Lorsban }	50	Calcium C}	360	Gusathion }	100	Calcium C	360
	Citowett }	25	Captan }	100	Citowett }	10	Captan }	100		
			Pallitop }	350			Bayleton }	25	Calcium C	360
	Captan }	100	Calcium C }	360	Calcium C}	360	Calcium C }	360		
	Lorsban }	225			Citowett }	10			Calcium C	360
	Calcium C}	360	Captan	100			Lorsban }	75		
					Gusathion }	375	Captan }	100	Dithane }	150
	Captan }	100			Captan }	500	Bayleton }	25	Lorsban }	50
	Pallitop }	150					Calcium C }	360	Bayleton }	25
	Calcium C}	360			Captan }	100			Calcium C}	360
					Lorsban }	50				
	Captan }	100							Captan }	100
	Gusathion}	300							Gusathion}	100
	Calcium C}	1600							Bayleton }	25
									Calcium C}	360
February	Captan }	100	Bayleton }	25	Gusathion }	375	Captan }	100	Calcium C}	360
	Lorsban }	75	Captan }	100	Captan }	500	Calcium C }	360	Captan }	100
	Calcium C}	360	Lorsban }	50						
	Fertilon }	100	Calcium C }	360	Calcium C }	360				
					Citowett }	10				
	Septan	100								
					Calcium C }	360				
	Fertilon	100			Citowett }	10				
	Combi									

TABLE 8.22: Spray Programmes : Hawkes Bay Growers 1986/87

Growers Month	I Chemical	ml, g/100L	II Chemical	ml,g/100L	III Chemical	ml, g/100L	IV Chemical	ml, g/100L	V Chemical	ml, g/100L
September	Lorsban }	75	Oil }	2.5L	Lorsban }	75	Syllit }	80	Copper	500
	Polyram }	150	Copper	500	Oil }	2.5%	Lorsban }	100	Oxychloride	
	Baycor }	20	Oxychloride}						(August)	
			Lorsban }	75						
									Oil }	4L
			Syllit	80					Apollo }	40
									Lorsban }	100
			Polyram }	150						
			Baycor }	20					Syllit	80
									Pallinal }	200
									Baycor }	20
October	Polyram }	150	Pallinal	150	Captan }	125	Topas	200	Pallinal }	200
	Baycor }	20			Bayleton }	50			Baycor }	20
			Polyram }	150			Baycor }	20		
	Polyram }	150	Baycor }	20	Captan	125	Polyram }	150	Pallinal }	200
	Baycor }	20							Baycor }	20
			Agrimycin	60	Captan }	125	Agrimycin }	60		
	Lorsban }	75			Nimrod }	50			Pallinal }	200
	Dithane }	125	Pallinal }	150			Polyram }	150	Baycor }	20
	Baycor }	20	Baycor }	20			Baycor }	20		
							Bayleton }	50	Agrimycin}	60
	Dithane }	125	Septan	75						
	Baycor }	20							Pallinal }	200
			Pallinal }	150					Baycor }	20
			Polyram }	150						
			Lorsban }	75						

TABLE 8.22: Continued: Spray Programmes : Hawkes Bay Growers 1986/87

Growers Month	I Chemical	ml, g/100L	II Chemical	ml,g/100L	III Chemical	ml, g/100L	IV Chemical	ml, g/100L	V Chemical	ml, g/100L
November	Dithane }	125	Pallinal }	150	Captan }	125	Carbaryl	80	Pallinal }	200
	Baycor }	20	Lorsban }	75	Nimrod }	50			Gusathion}	75
					Estenvale}	30	Polyram }	150		
	Dithane }	125	Pallinal }	150	-rate }		Baycor }	20	Pallinal }	200
	Bayleton}	50	Lorsban }	75			Bayleton }	50	Gusathion}	75
	Syllit }	80			Captan }	125				
					Nimrod }	50	Polyram }	150	Lorsban }	100
	Lorsban }	75	Blind	175			Baycor }	20	Pallinal }	200
	Dithane }	125					Bayleton }	50	Calcium N}	600
	Syllit }	80	Calcium N}	500			Lorsban }	50		
							Dithane }	125		
December	Lorsban }	75	Calcium N	500	Esfenvale-	30	Lorsban }	50	Lorsban }	100
	Dithane }	125	Calcium N	500	rate }		Dithane }	125	Pallinal }	200
	Syllit }	80			Syllit }	80			Calcium N }	600
			Peropal }	50	Nimrod }	50	Lorsban }	50		
	Syllit }	80	Captan }	100			Dithane }	125	Gusathion }	75
	Orthocide}	400			Captan	100			Syllit }	80
			Blind	175			Lorsban }	50	Calcium N }	600
	Syllit }	80					Dithane }	125		
	Orthocide}	400	Blind }	175					Blind }	175
			Bayleton }	50			Lorsban }	50	Calcium N }	600
							Dithane }	125		

TABLE 8.22: Continued: Spray Programmes : Hawkes Bay Growers 1986/87

Growers	I		II		III		IV		V	
Month	Chemical	ml, g/100L	Chemical	ml,g/100L	Chemical	ml, g/100L	Chemical	ml, g/100L	Chemical	ml, g/100L
January	Syllit }	80	Blind }	175	Captan	100	Polyram }	150	Blind }	175
	Orthocide}	400	Calcium C}	360			Lorsban }	50	Calcium C }	350
					Esfenvale-	30	Calcium C }	600		
			Blind	175	rate }				Blind }	175
					Captan }	100	Polyram }	150	Calcium C }	350
			Blind }	175			Lorsban }	50		
			Bavistin }	25			Calcium C }	800		
			Peropal }	50						
							Syllit }	60		
			Calcium C	360			Lorsban }	50		
			Calcium C	360			Calcium C }	800		
February	-		-		Captan }	125	Syllit }	60	Blind }	175
					Nimrod }	50	Lorsban }	50	Calcium C }	350
							Calcium C }	600		
									Septan }	75
							Carbaryl }	75	Calcium C }	350
							Calcium C }	600		

TABLE 8.23: Cost of pest and disease control in monitored orchards ($/ha)*

Specification***	Canterbury		Nelson		Hawkes Bay	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Labour	102.00 (12.0)	162.00 (7.5)	84.00 (6.4)	180.00 (8.3)	108.00 (9.1)	149.50 (7.7)
Machinery (tractor and sprayer)	306.00 (36.1)	486.00 (22.4)	252.00 (19.2)	540.00 (27.8)	324.00 (27.3)	414.00 (21.3)
Chemicals	440.80 (51.9)	1,517.20 (70.1)	977.10 (74.4)	1,454.30 (66.9)	752.80 (63.6)	1,377.90 (71.0)
Total Direct Costs	848.80 (100.00)	2,165.20 (100.00)	1,313.10 (100.00)	2,174.30 (100.00)	1,184.80 (100.00)	1,941.40 (100.00)
Number of applications	14	19	14	22	12	19
Cost per application	60.63	113.96	93.79	98.83	98.73	102.18
Equivalent in kg of Royal Gala apples**	2,106.20	5,888.50	4,066.60	5,960.30	4,481.10	6,065.60

* 1986/87 Programmes and Costs
Percentage of total direct costs in brackets.

** Based on gross return according to 1986/87 average NZAPMB prices adjusted for fruit size in the respective orchards.

*** Lowest and highest costs in the respective districts.

TABLE 8.24: **Weed control in monitored orchards**

Herbicides	Rates/ha	Canterbury I	II	III	IV	V	Nelson I	II	III	IV	V	Hawkes Bay I	II	III	IV	V
Simazol	3L		X (Oct)													
Preglone	3L				X (Dec)						X (Dec)					
Roundup	1-2L	X (Sep)				X (Nov)	X (Nov)	X (Nov)	X (Nov)			X (Nov)		X (Nov)		
Simazine	3-5L		X (Jan)			X (Sep)	X (Sep)		X (Sep)						X (Oct)	
Gesagard	6L	X (Sep)		X (Sep)				X (Sep)			X (Sep)		X (Sep)			
Weedazol	3L			X (Sep)		X (Sep)		X (Sep)		X (Sep)	X (Sep)		X (Sep)	X (Sep)	X (Sep)	X (Sep)
Amitrole	2-3.5L				X (Nov)		X (Sep)			X (Sep)						
Goal	3L				X (Aug)											
Versatill	1L				X (Oct)											
Sinbar	3L											X (Sep)				X (Sep)

X - herbicide application, months in brackets.

TABLE 8.25: Fertilisers used in monitored orchards*

Growers in districts										
Canterbury					Nelson					Hawkes Bay
I	II	III	IV	V	I	II	III	IV	V	I - V
Lime 3500 kg/ha (September	Superphosphate 5t (September) Potash 750 kg 750 kg (September)	Urea 100 kg/ha (September) MgO 125 kg/ha (November) Urea 125 kg/ha (November)	Lime 1750 kg/ha (May) Ammonium Sulphate 200 kg/ha (August) Superphosphate 104 kg/ha Urea 100 kg/ha (October)	Urea -2x 130 kg/ha (December and January)	Lime - 831/kg Sulphur - 74 kg Borate 48-20 kg Zinc Sulphate - 50 kg Copper Sulph. - 25 kg. Total 1.1 ton mix (October) Calcium Ammonium Nitrate and Muriate of Potash (December)	Orchard Fertiliser (8-4-8-13%) Plus Sulphate 1.28 kg/tree (August and December)	Lime 5t/ha every 4 yrs Fertiliser (16-8-6%) 750 kg/ha (September)	Superphosphate 1005 kg/ha Potassium Chloride 50 kg/ha (June) Fertiliser (12-10-10%) 3.6 kg/tree (September)	Ammonium Sulphate plus Borate 1.2 kg/tree Urea 0.5 kg/tree (November)	Nil

*Some growers have applied foliar sprays using Fertilon (100g/100L), Fertiliser Combi (0.7 - 1 kg/ha) and Foliar Nitrophoska (300 - 400 ml/100L) (see Tables 8.21 and 8.22) and $Ca(NO_3)_2$ through trickle irrigation (Grower C/II in February).

TABLE 8.26: Suggested maintenance fertiliser rates for established pip fruit and nutrient removal in a 10 tonne/ha crop

Element	MAF Soil Test Level	Application Rate	Crop Removal kg/ha
Nitrogen		(kgN/ha)	6-11
	-	80-100	
Phosphorus		(kgP/ha)	0-7.1.4
	>70	-	
	30-70	50	
	10-30	100	
	<10	250	
Potassium	Soils with low K reserves*	(kgK/ha 10 tonne crop)	10-15
	a. K<0.5 x Ca	20- 30	
	b. K>0.6 x Ca	7- 20	
	c. K intermediate between a. and b.	15- 20	
	Soils with high K reserves*		
	a. K<0.5 x Ca	12- 15	
	b. K>0.6 x Ca	-	
	c. K intermediate between a. and b.	7- 10	
Calcium	-	-	0.3-0.7

Source: Clark et al

* Recent soils and those from grey-wacke and schist have high K reserves; peats and strongly weathered and leached soils with granite or volcanic parent materials have low K reserves.

Appendix 3: Regression Figures **Page**

Figure 8.1:Butt Cross-sectional Area vs Total Yield - all Districts

Correlation Coefficient = 0.694

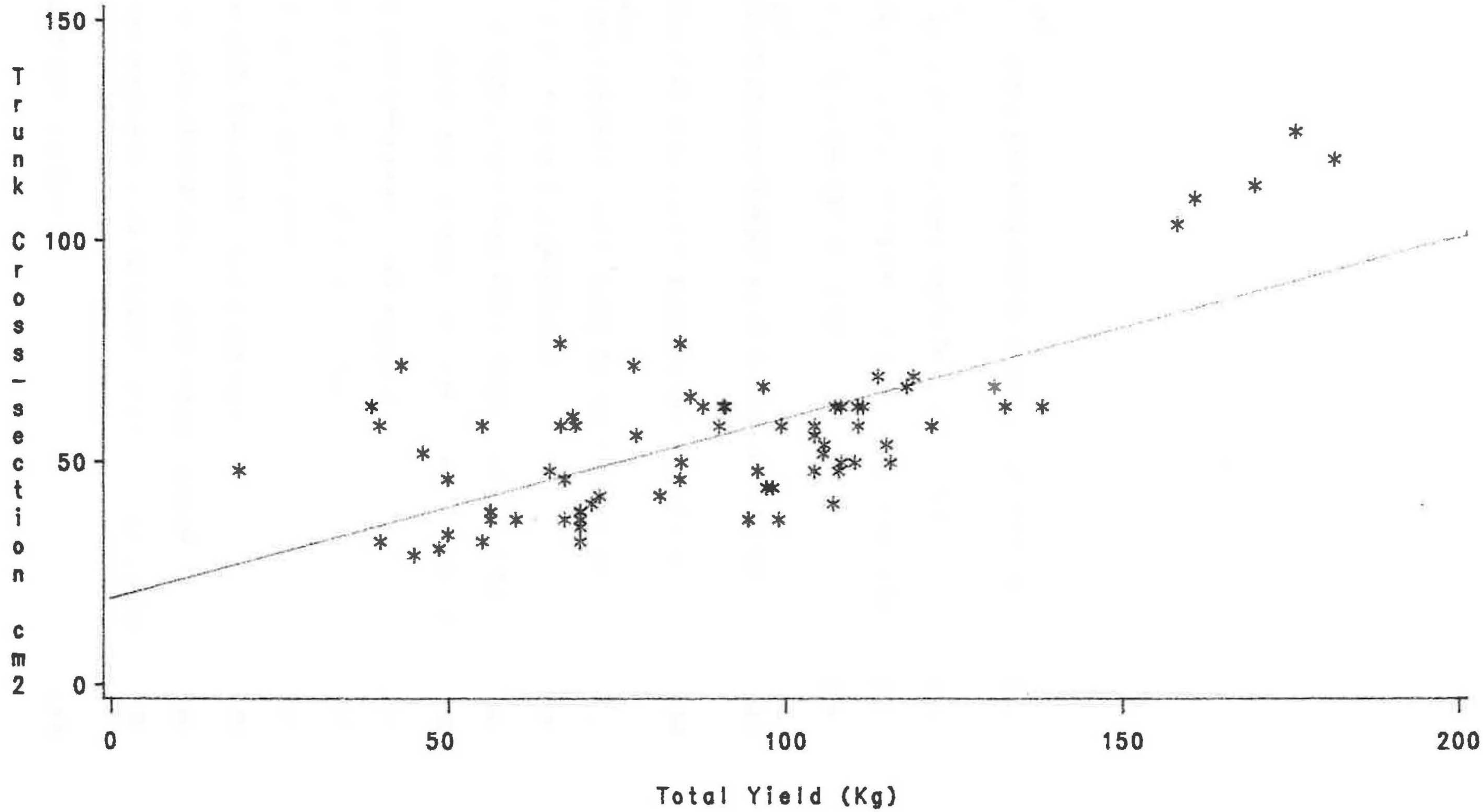


Figure 8.2;Butt Cross–sectional Area vs Total Yield – Nelson

Correlation Coefficient = 0.813

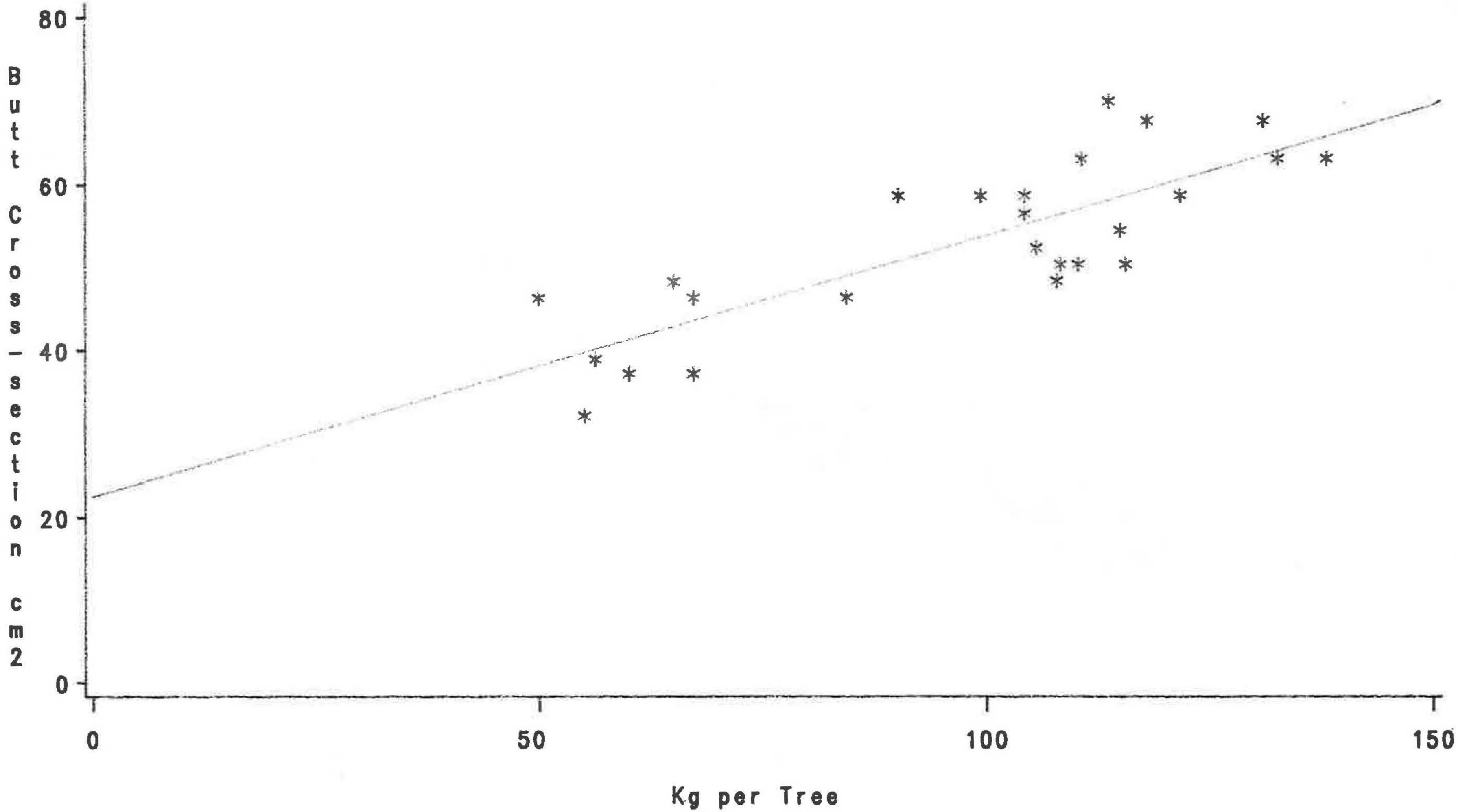


Figure 8.3: Yield vs Fruit per Tree – all Districts

Correlation Coefficient: 0.964

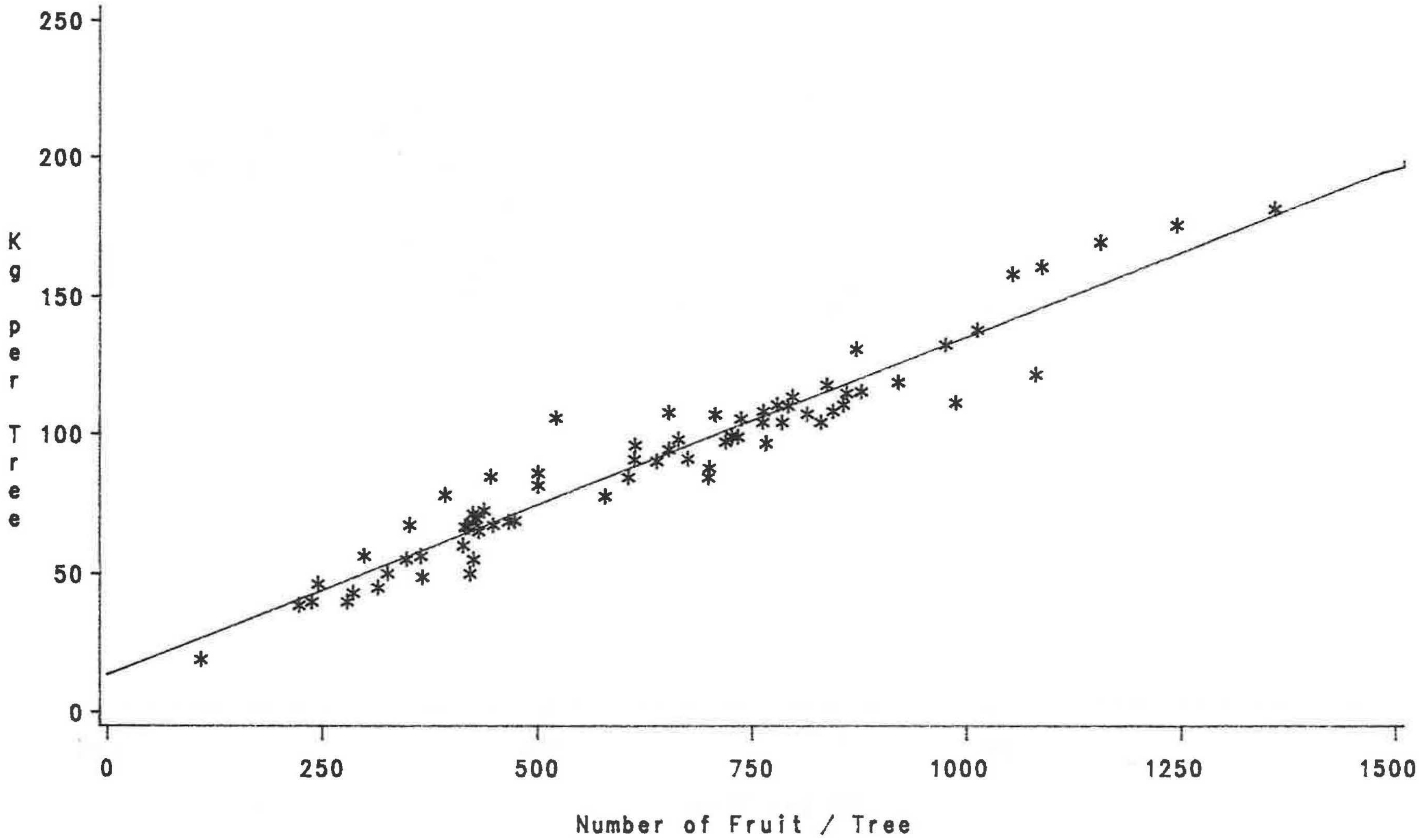


Figure 8.4: Yield vs Fruit Number / Tree – by Districts

Correlation Coefficients: Canty 0.951 Nelson 0.962 H/Ba .971

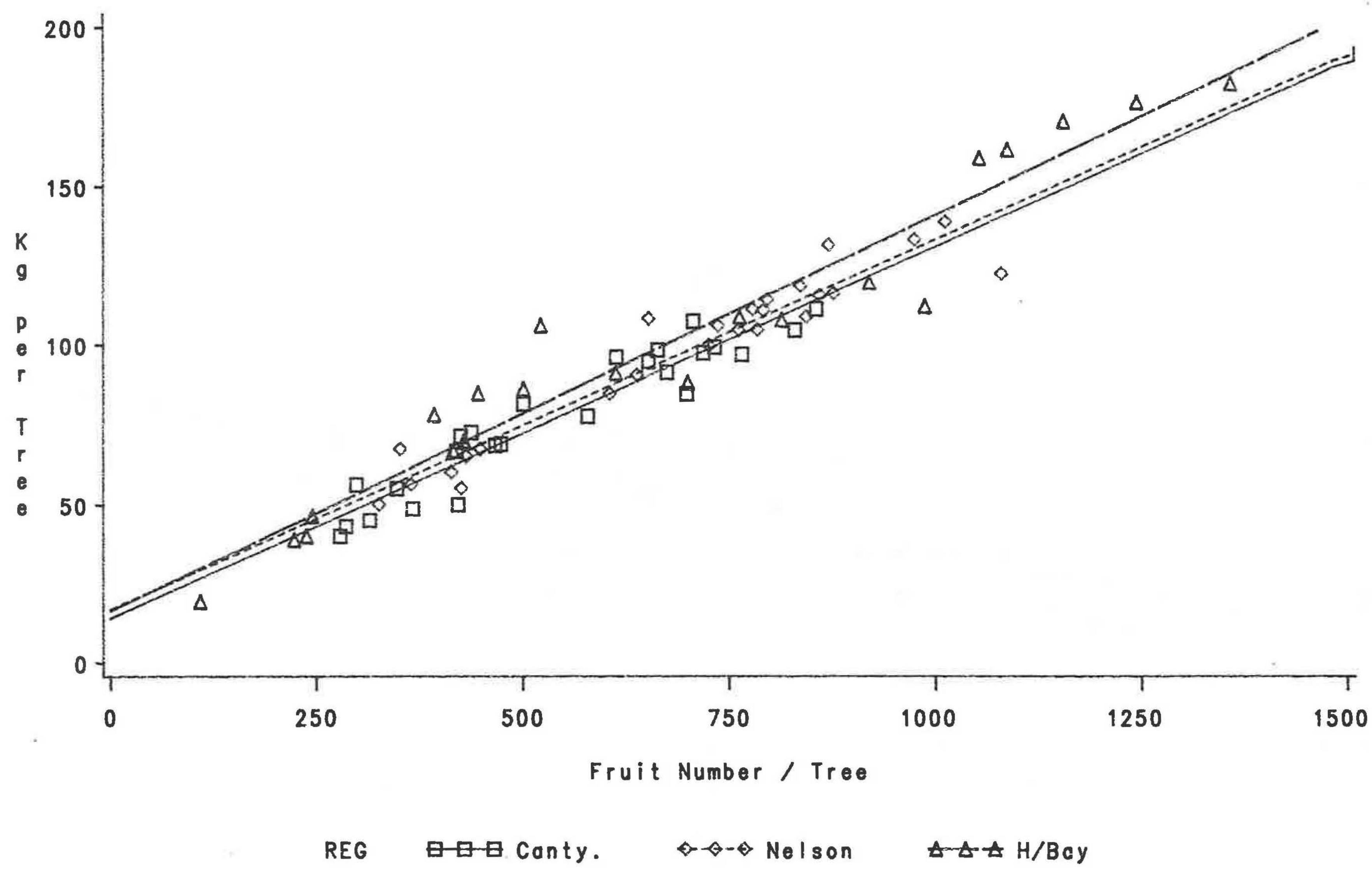


Figure 8.5: Yield vs Crop Load Index – all Districts

Correlation Coefficient: 0.694

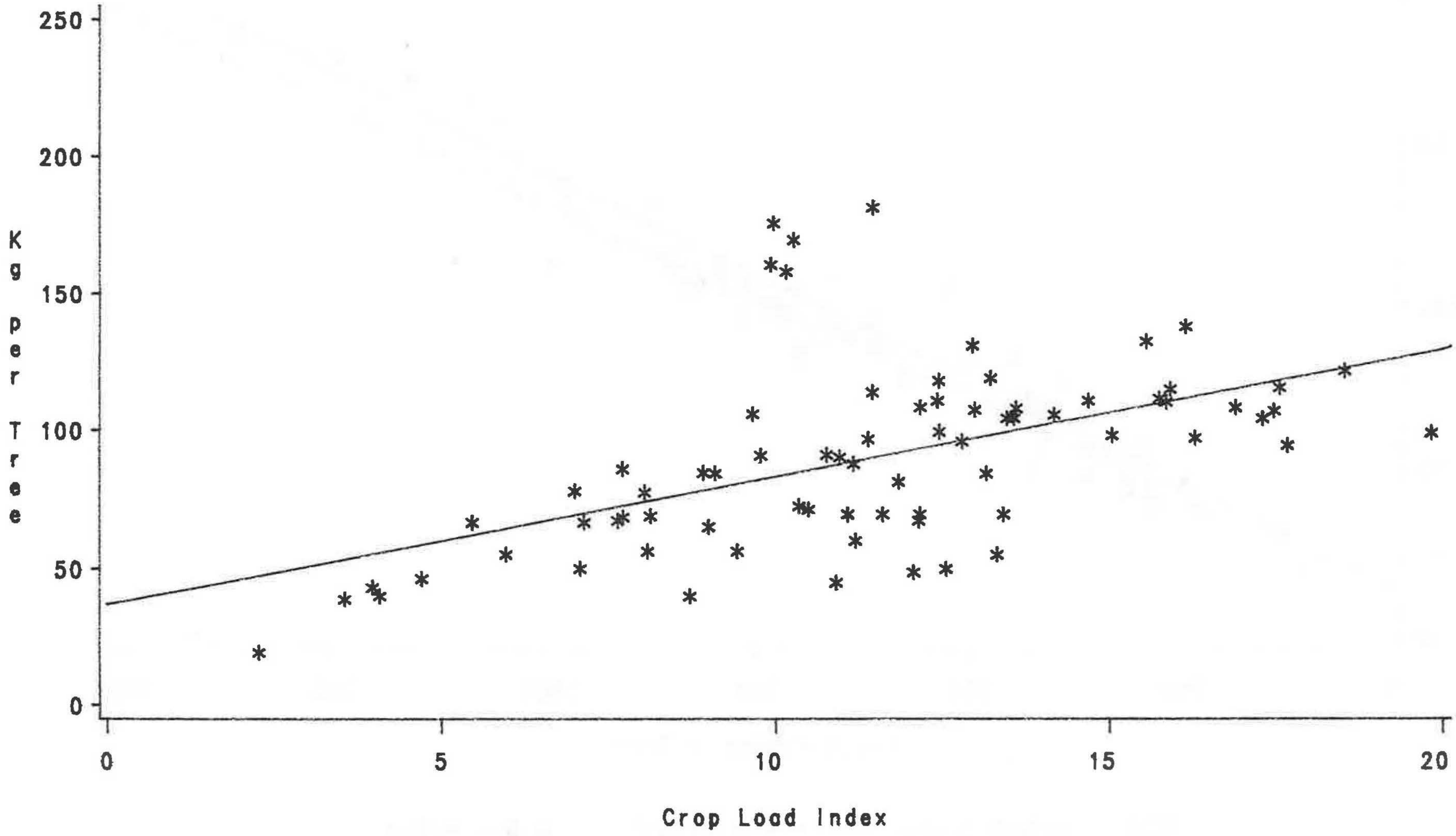


Figure 8.6: Yield vs Crop Load Index — by District

Correlation Coefficients: Canty 0.678 Nelson 0.706 H/Bay 0.514

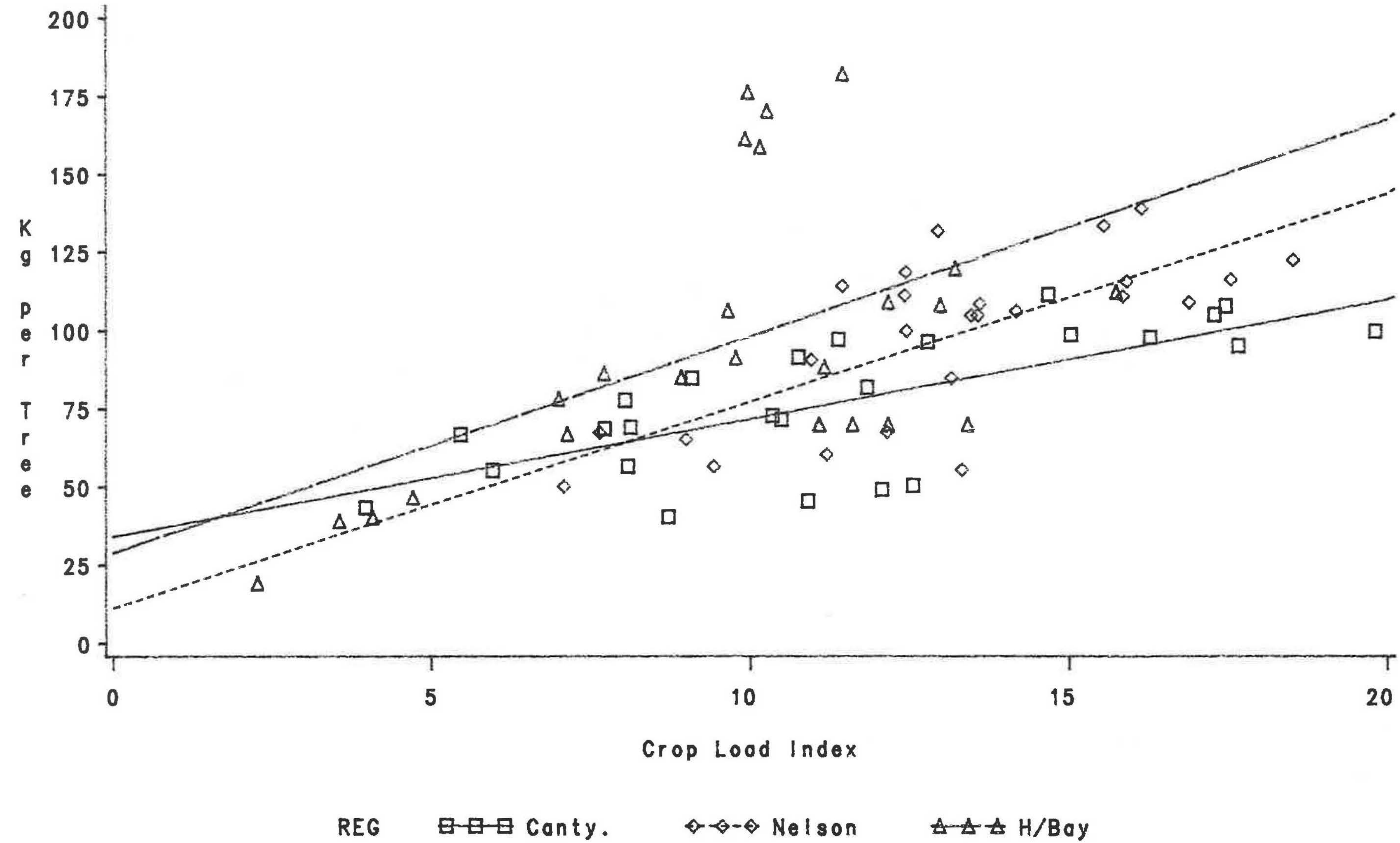


Figure 8.7: Average Fruit Weight vs Crop Load Index – all Districts

Correlation Coefficient : –0.588

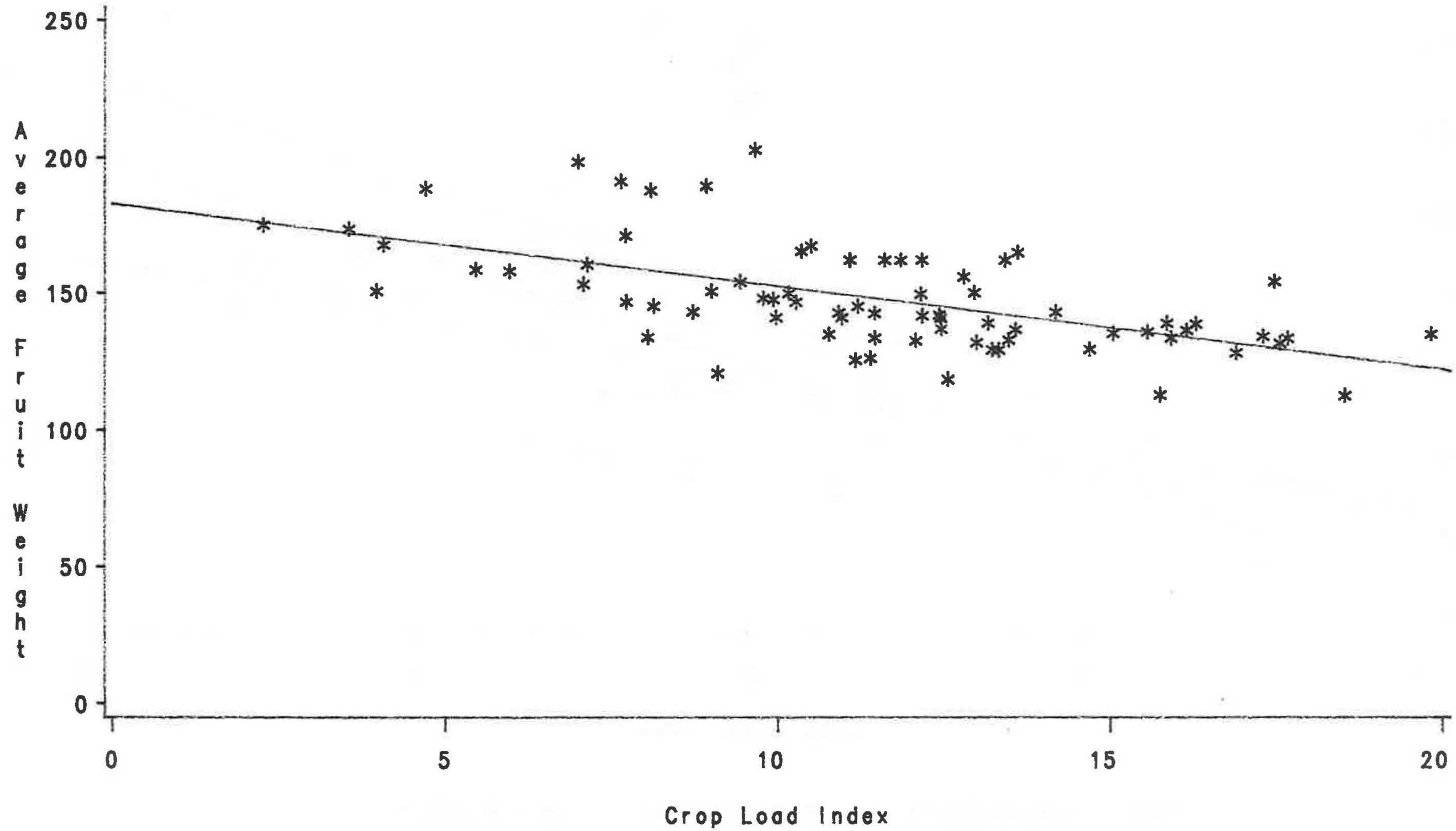


Figure 8.8: Crop Load Index vs % ExportGrade Fruit – by District

Correlation Coefficients: Canty –0.216 Nelson –0.730 H/Bay –0.763

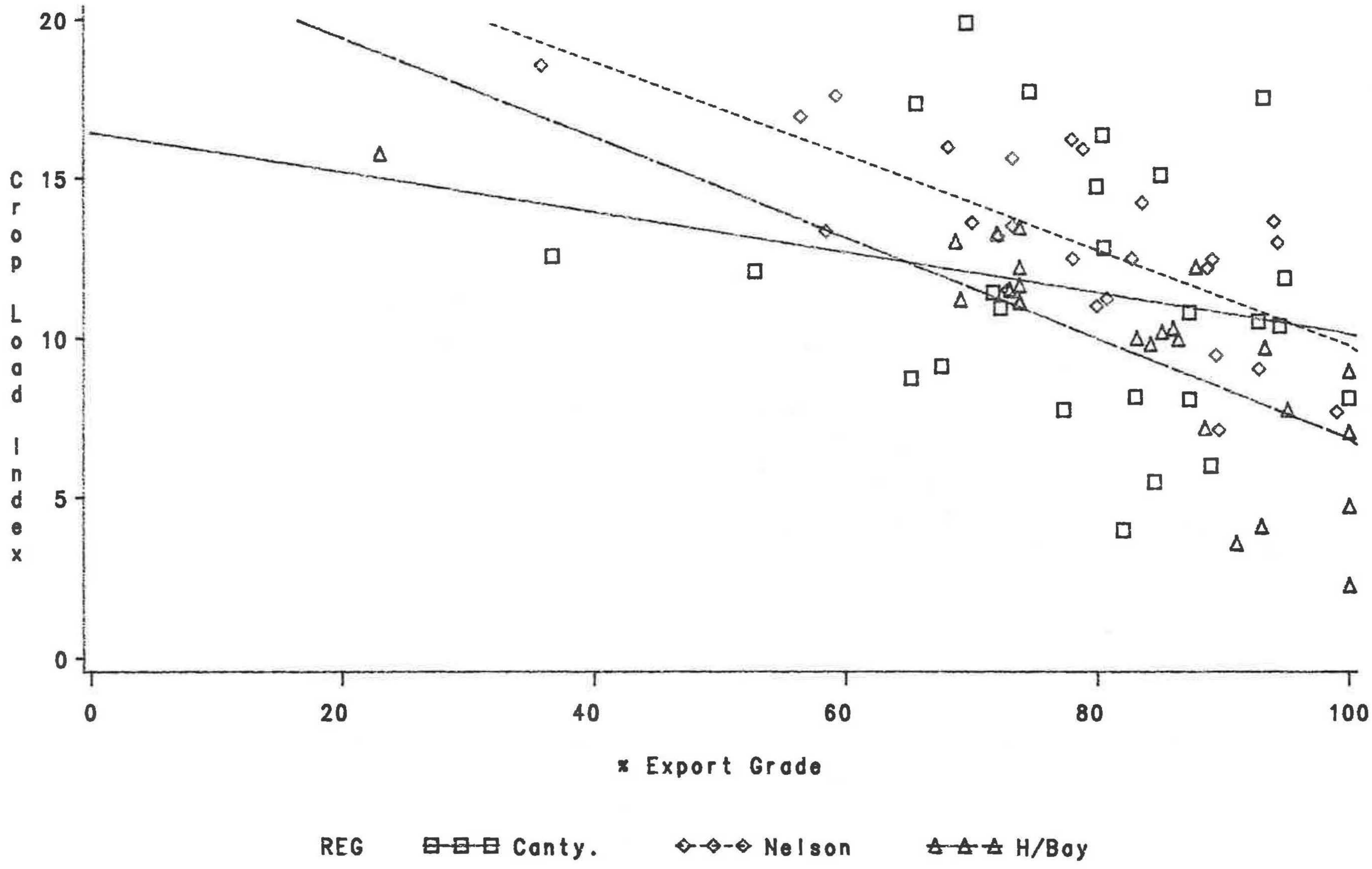


Figure 8.9: Initial Fruit Set vs CLI
Canterbury

Correlation Coefficient: 0.572

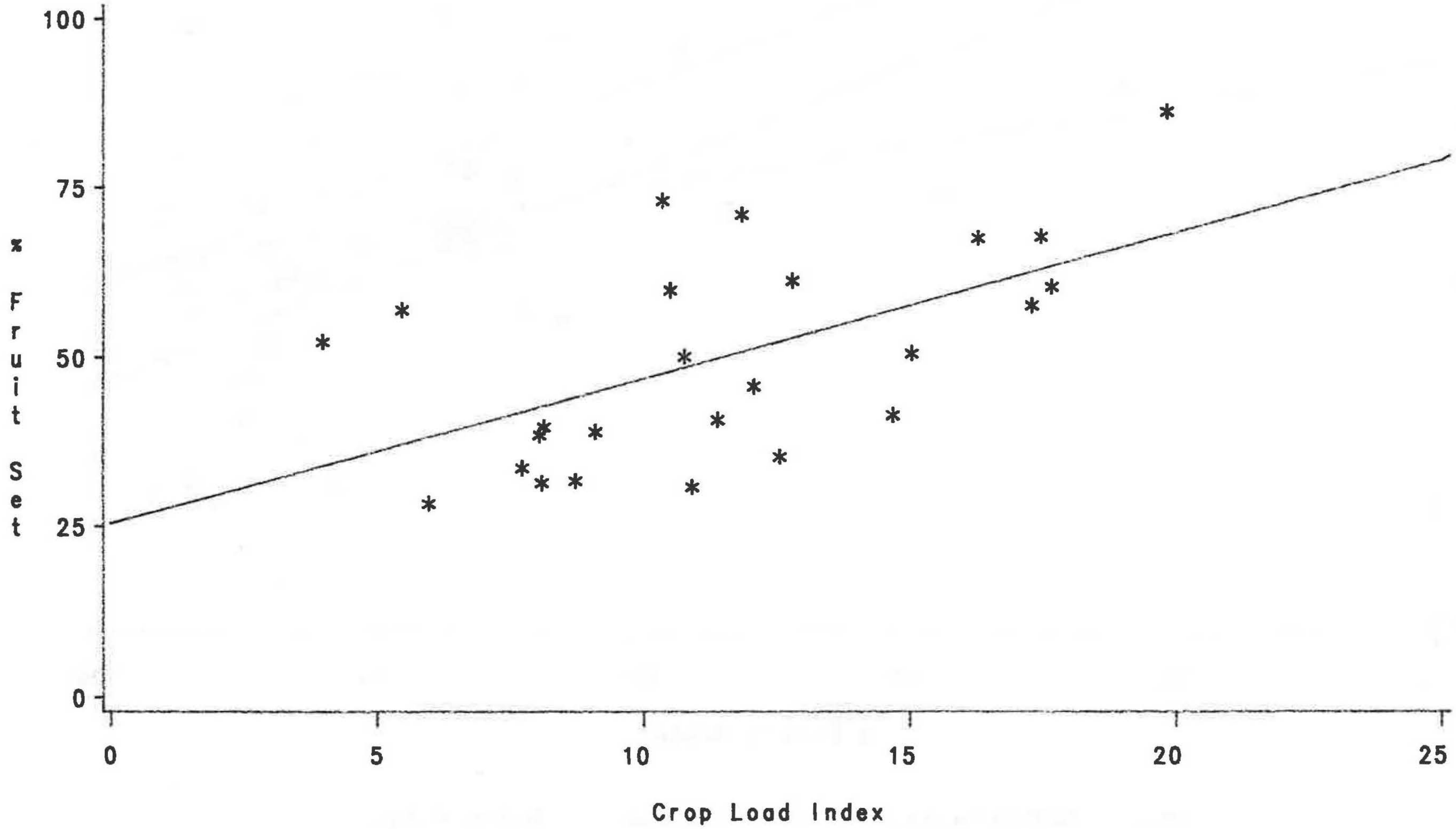


Figure 8.10: Relationship Between Yield, Fruit Wt.and CLI in Canterbury

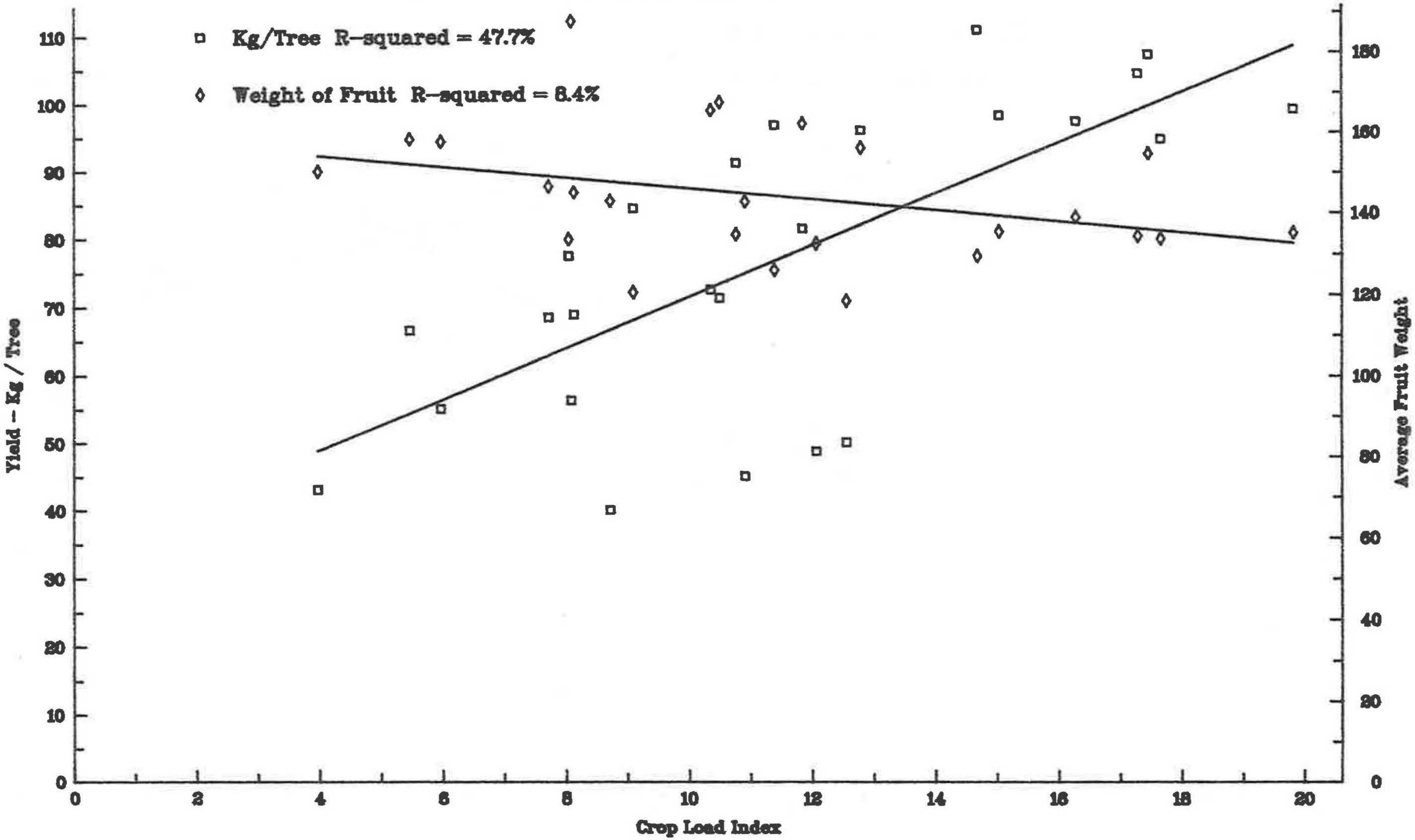


Figure 8.11: Relationship between Yield, Fruit Wt.,and CLI in Nelson

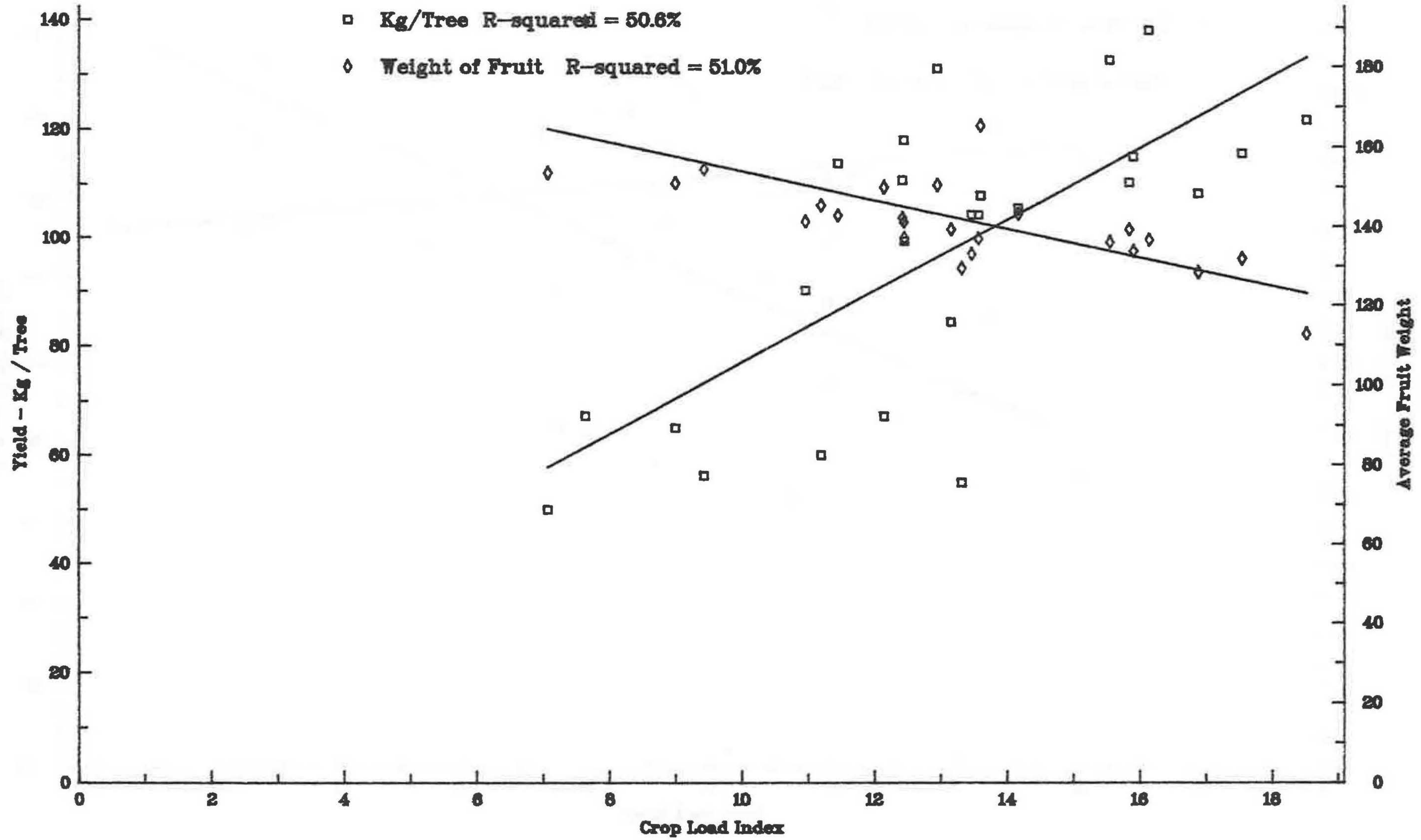


Figure 8.12: Relationship between Yield, Fruit Wt.,and CLI in Hawkes Bay

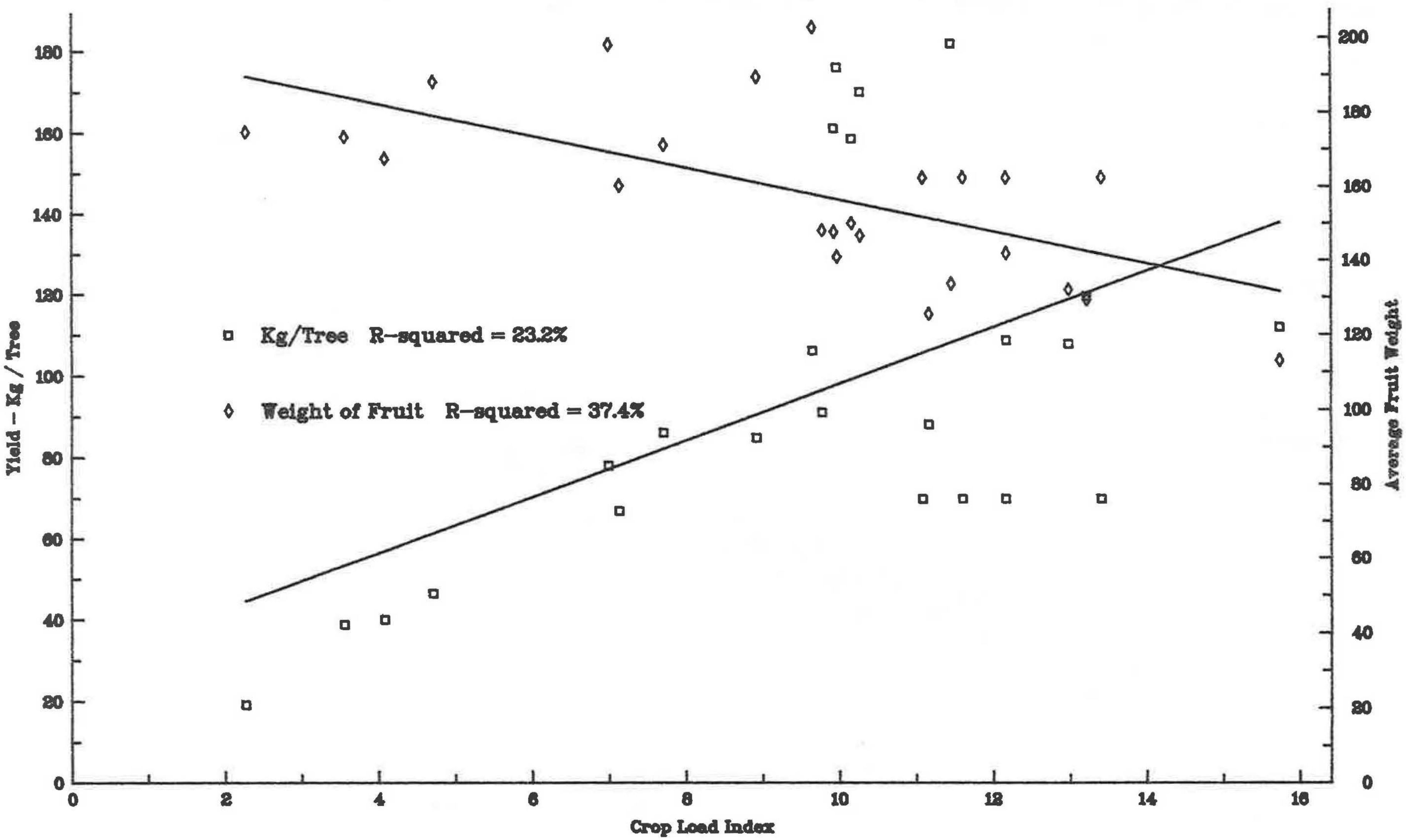


Figure 8.13: Yield vs Fruit Value ($) per Tree – by District

Correlation Coefficients; Canty 0.958 Nelson 0.841 H/Bay 0.912

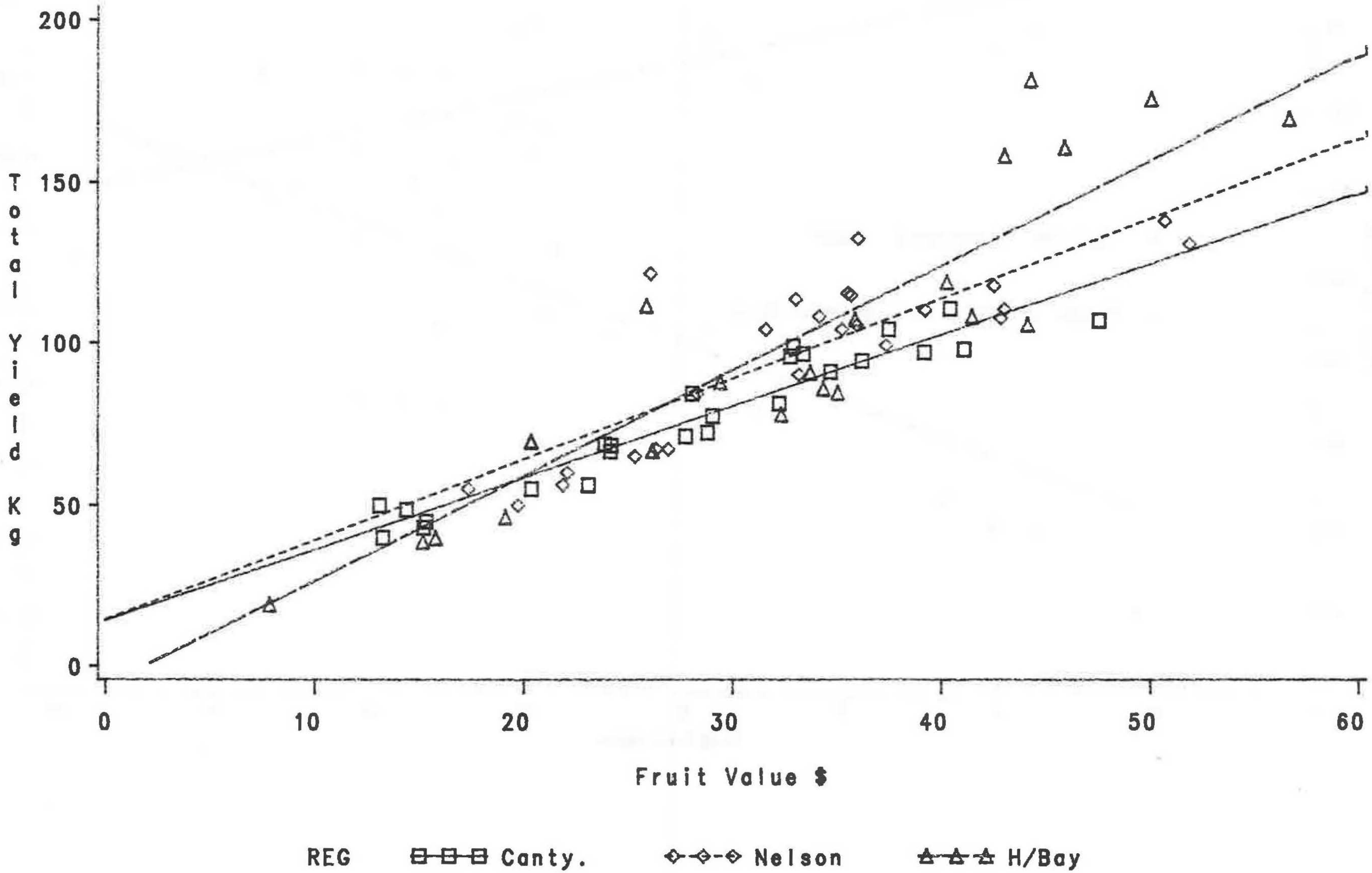


Figure 8.14: Number of Fruit/Tree vs Value per Tree – all Districts

Correlation Coefficients: Canty 0.854 Nelson 0.695 H/Bay 0.831

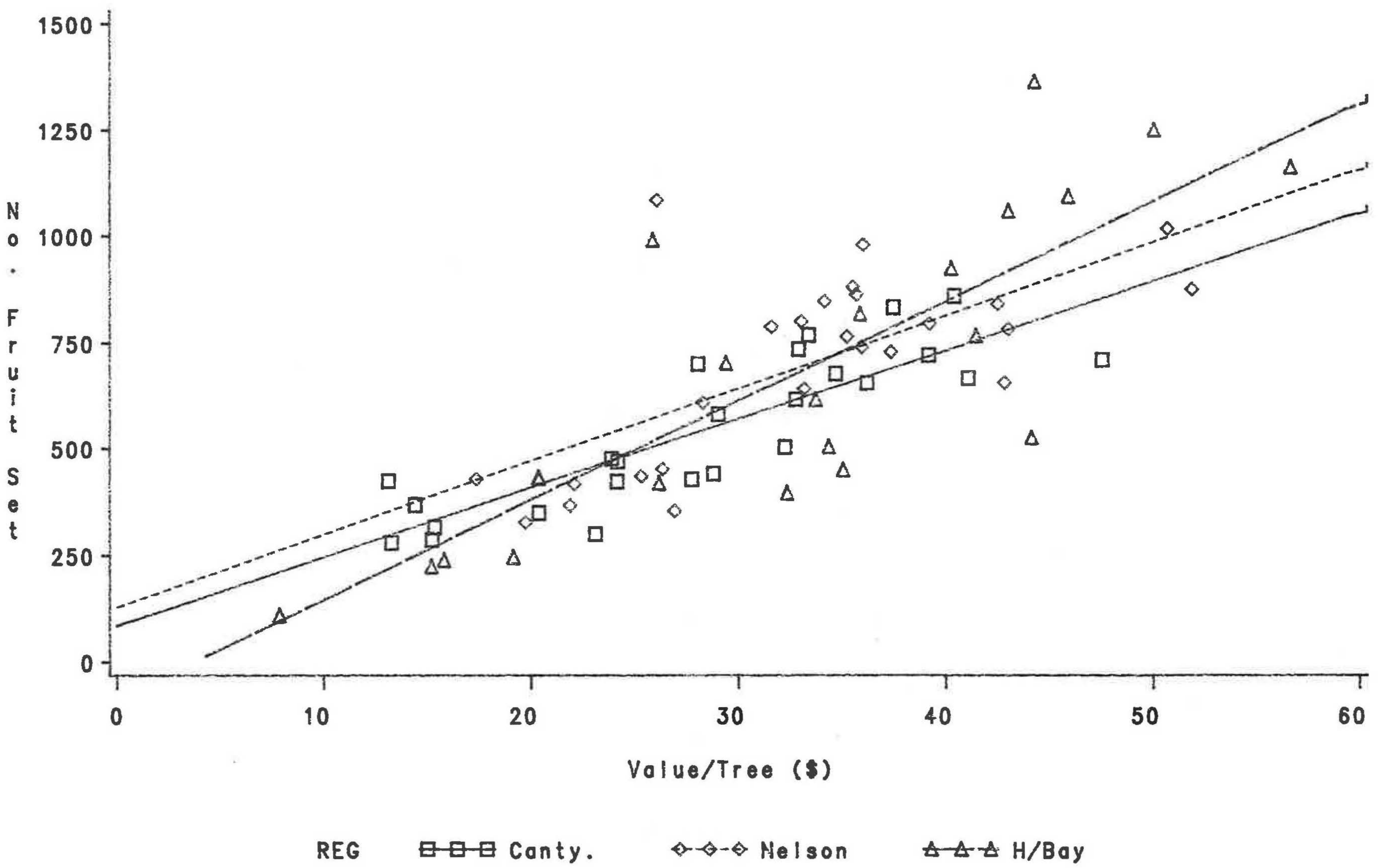


Figure 8.15: Initial Fruit Set vs Fruit Value per Tree – all Districts

Correlation Coefficient: 0.159

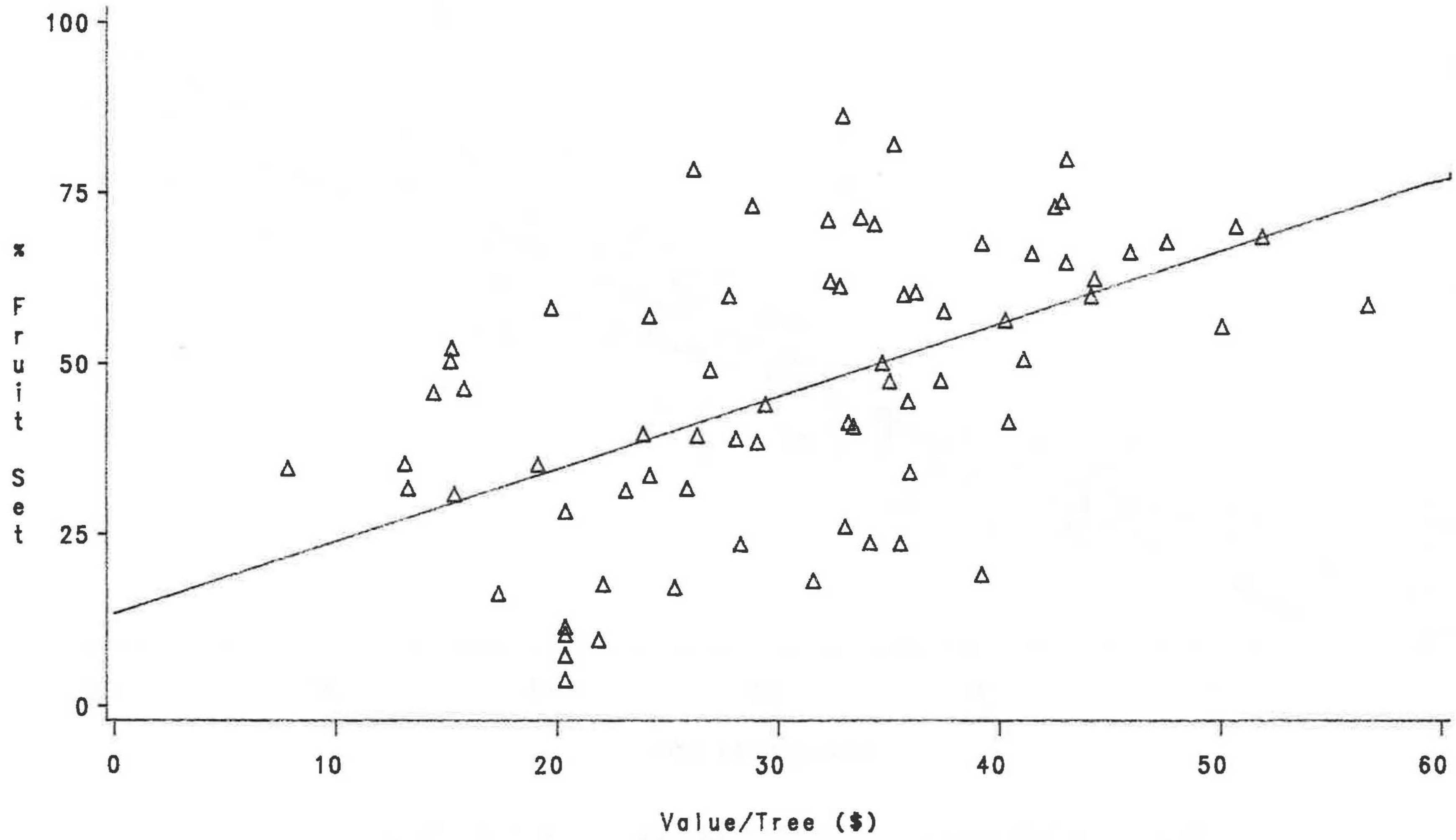


Figure 8.16: % Fruit in First Two Pickings vs Fruit Value/Tree
Hawkes Bay

Correlation Coefficient: −0.737