Report to Zespri Innovation Company Ltd

An Analysis of Zespri's 2003 Organic Kiwifruit Database: Factors Affecting Production

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Summary

The Zespri database for the 2002-2003 growing season, containing information on 185 organic Hayward Green and 35 organic Hort16A orchards was analysed to produce summaries of variables such as the percentages and production levels of fruit in each size over all orchards. These variables were also related to the spray regimes used for mineral oil and Bt spray and the geographical location.

As the data were not taken from controlled and designed scientific experiments the results demonstrating relationships between spraying regimes and location and production variables do not show cause and effect, but should be taken as indications of what *might* be happening in these orchards.

For organic Hayward Green it was found that:

- There was no relationship between fruit size and orchard production in trays per hectare.
- There was no relationship between the percentage of larger fruit and orchard production in trays per hectare.
- There was no relationship between fruit size and achievement of a Taste Zespri premium.
- There was no relationship between the percentage of larger fruit and achievement of a Taste Zespri premium.
- One quarter of the fruit produced on Hayward Green orchards were of size 39 (i.e., 39 fruit to the tray).
- 33 percent of the fruit produced was of a bigger fruit size (i.e., less than size 36).
- The average size was 35.8 fruit per tray.
- Most orchards either recorded KiwiStart compensation for picking early fruit, or a Taste Zespri premium for *most* of their fruit or *none at all*, with very few in between.
- Receiving one premium did not relate to receiving the other.
- The average orchard produced 13,796 trays of fruit.
- This translated into 4,177 trays per hectare.
- The average orchard size was 3.8 hectares.
- Mineral oil was used an average 0.9 times *before* full bloom, and 2.3 times *after* full bloom.
- Statistical analyses indicate that applications of mineral oil *before* full bloom may affect the percentage and trays per hectare of larger fruit, the average fruit size, the percentage of Taste Zespri fruit, and the trays per hectare production.
- Most growers did not use Bt spray *before* full bloom but averaged 2.7 applications *after* full bloom.
- Probably altitude and the further to the west or south that the orchard is located limits the production of larger fruit and the possibility of producing fruit suitable for KiwiStart.
- Altitude and location did not appear to limit the total production in trays per hectare or the attainment of the Taste Zespri premium.
- There was no consistent evidence that the size of an orchard canopy or the total number of trays per orchard meant more efficient production or the production of a greater percentage of larger fruit, or a larger average fruit size, or a greater percentage of fruit receiving KiwiStart compensation or Taste Zespri premiums.

For organic Hort16A it was found that:

- One third of all fruit was of size 36.
- 34 percent of the fruit produced was larger fruit (i.e., less than size 36).
- The average size was 35.3 fruit per tray.
- Most orchards either recorded a KiwiStart or a Taste Zespri premium for *most* of their fruit or *none at all*, with very few in between.

- Receiving one premium did not relate to receiving the other.
- The average orchard produced 8,300 trays of fruit.
- This translated into 3,847 trays per hectare.
- The average orchard size was 1.9 hectares.
- Mineral oil was used on average 1.4 times *before* full bloom and 1.3 times *after.*
- Bt spray was used on average 2.7 times *after* full bloom. Most Hort16A orchardists did not use Bt *before* full bloom.
- Two applications of mineral oil compared with one *before* full bloom appear to be producing a greater percentage of larger fruit, and increasing the average fruit size, however, it seems to adversely affect production of trays per hectare.
- No applications of mineral oil *after* full bloom compared with two applications appears to be increasing the percentage of KiwiStart fruit
- Three applications compared with none increases the production of trays per hectare, and trays per hectare of larger fruit.

Many suggestions are made for ways in which this data could be further explored, and developed.

Chapter 1
Introduction and Methods of Analysis

1.1 Introduction

A database of many variables collected by Zespri from their organic kiwifruit growers and the packhouses was put at our disposal for 'data dredging'. This database contained the breakdowns for each orchard of its total production (total trays) by grade, size, and achievement of KiwiStart compensation and Taste Zespri premiums. The altitude and GPS coordinates of each orchard, the recording of the dry matter content for samples taken of all fruit, and a full description of the spray regime followed by each orchard containing the date of full bloom and the timing of each spray were provided. Later we were given the size of each orchard, data which mainly came from the BioGro database, supplemented from other sources found by Stuart Kay.

Hence, the objective was to find anything that might be of interest to organic kiwifruit growers. This was understood to mean that it would be useful to have a summary of the actual range of organic kiwifruit production across orchards according to different ways of considering fruit size, production levels and the achievement of premiums. Then any relationships between different data sets that again describe organic kiwifruit production in New Zealand and that may suggest certain factors that might be enhancing the production of larger fruit or more fruit, were explored.

1.2 Process and Methods

Much time was spent getting this data into a format that could be summarised and analysed in ways that might provide some useful information. First, it was split into separate Hayward Green and Hort16A databases. Then it was arranged in a different way so that information about each orchard was provided in columns of different variables, such as the total trays per orchard, the percentages of Grade 1 and Grade 2 fruit, the percentages in each fruit size within each grade and the percentages of KiwiStart and Taste Zespri fruit. This enabled frequency tables of these variables to be produced. Also it means that fruit size profiles for each orchard are available.

When the orchard size data became available it was possible to calculate measures of production using trays per hectare, enabling all the variables above to be recalculated in this format. Again frequency tables were produced.

It was decided that it would be of interest to growers to have the spray data split into the number of times spray was applied before and after full bloom. Frequency tables for these variables were then produced for mineral oil and Bt spray. These data could then be used to perform one-way analysis of variances (ANOVAs) to test whether the number of spray applications significantly affected any of the fruit production variables. Graphs were drawn to illustrate some of these relationships. These analyses were only performed for applications of mineral oil as the group advising us could not any biological reasons why Bt spray should affect any of the production variables.

In addition scattergrams were plotted to study the relationships between altitude and GPS coordinates to the main production variables to see how production might be limited by an orchard's location. This method was used because straight correlations can show significant

relationships which when plotted on a graph show that the relationship is not linear, and/or is dependent on one or two outliers.

1.2.1 Limitations of the Data

It must be pointed out that the results of this analysis do not come from designed experiments carried out with strict controls of any intervening variables and so any significant relationships between variables are purely exploratory and could be confounded with other variables not accounted for in the analysis. For example, no data was given about whether the orchards had t-bar or pergola systems of vine management. Also, there is no way of knowing if the production was affected by other factors such as new vines coming into production. 2002 was the first year for participation in Taste Zespri so all orchards may not have yet been participating in this scheme at the time of this database which represents the 2002-2003 season. There was no information given on the incidence of pests which could be related to shelter belt species and the proximity of native bush. Pests also arrive later at higher altitudes. Hence results could be regarded as suggestions for future designed experiments.

The data is also limited by possible inaccuracies in the orchard size data which was not readily available from one source. It was not clear from it whether it was a measure of canopy cover, or if it related to more than one property.

This report goes on to produce analyses of each type of kiwifruit, Hayward Green and Hort16A, or Kiwi Gold as it is known. The Hayward Green analyses are fuller than those for Hort16A and have been illustrated sometimes by graphs for easier visual appreciation of the data compared with tables but this has not been done for Hort16A data due to time and cost restraints.

Chapter 2
Results of the Analyses of the Organic Hayward Green Data

2.1 Introduction

In this chapter the results from analyses of the 185 orchards in the organic Hayward Green database are presented. There are summaries of the variables in the form of frequency tables, followed by a consideration of the relationships between some of these variables and the spraying regimes, and analyses of the limitations imposed by geographical location. The chapter concludes with a look at some correlations between variables of interest.

2.2 Summary of Variables

The summaries presented here in frequency tables and graphs are of fruit size in various configurations, KiwiStart and Taste Zespri percentages and production, total trays produced per orchard, and production per hectare, orchard size, geographical features and spray data.

2.2.1 Fruit Size Profiles

Table 2.1 and Graph 2.1 show the distribution of fruit production over all the orchards in the database according to the numbers of fruit produced per tray. For example, on average over 25 percent of the fruit produced is of size 39 (39 fruit per tray) closely followed by 22 percent of size 36. Most orchards struggle to produce significant percentages of fruit in the larger fruit sizes with only six percent (11 orchards) producing more than ten percent of their fruit in size 27, for example. Twenty three percent of orchards produced more than 30 percent of their fruit in size 39. Graph 2.1 demonstrates how the distribution is skewed with the most common fruit being of size 39, which is smaller than the average of 35.8 fruit per tray (Table 2.6).

Graph 2.1: Fruit profile

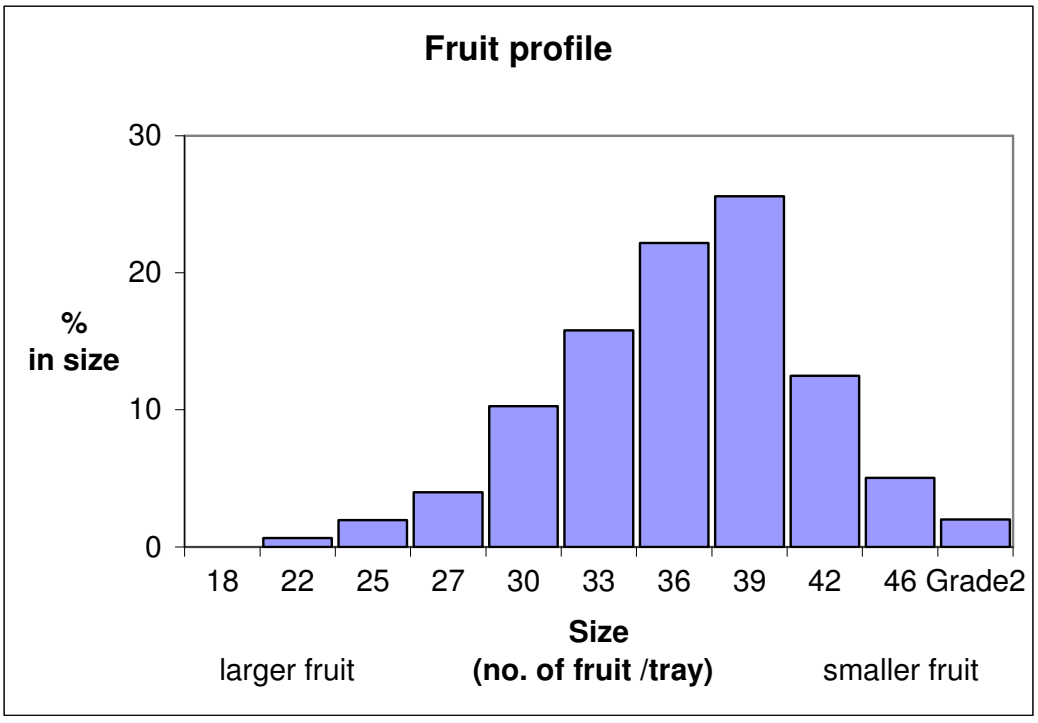


Table 2.1 also shows in greater detail how the percentages of fruit on each orchard are distributed according to size. For instance, it shows that 95 percent of orchards have less than two percent of their fruit in size 22, the largest size to register significantly in the data. However, 23 percent of orchards had more than thirty percent of their production in size 39. This table is interesting because it demonstrates how the percentages of fruit produced in an orchard change across the different fruit sizes. It can be seen how there are low percentages of larger fruit produced but as the fruit gets smaller the percentage an orchard produced in that size increases (up to size 39) and then reduces again as the fruit become even smaller.

Table 2.1: Percentage distributions of percentages of fruit in each size (N = 185 orchards)

% in this fruit size	Grade 1: % in each size									Grade 2 %
	22	**25**	**27**	**30**	**33**	**36**	**39**	**42**	**46**	
0 -	95	67	27	2	0	0	0	0	32	60
2 -	3	22	32	7	1	0	0	4	14	21
4 -	2	4	22	14	1	0	0	9	16	11
6 -	1	2	8	15	2	0	1	9	15	5
8 -	0	3	5	16	10	0	2	15	12	2
10 -	0	2	3	9	5	1	1	11	3	2
12 -	0	0	3	17	17	1	2	14	3	0
14 -	0	0	0	10	16	3	4	10	4	0
16 -	0	0	0	2	11	4	2	10	1	0
18 -	0	0	0	5	20	14	8	7	1	0
20 -	0	0	0	4	14	20	10	6	0	0
22 -	0	0	0	0	3	33	8	2	0	0
24 -	0	0	0	0	1	18	11	1	0	0
26 -	0	0	0	0	0	3	15	0	0	0
28 -	0	0	0	0	0	3	13	0	0	0
30 +	0	0	0	0	0	1	23	1	0	0
Total (%)	101	100	100	101	101	101	100	99	101	101
Average %	0.7	2.0	4.0	10.3	15.8	22.2	25.6	12.5	5.0	2.0

Note 1: The total percentages in all tables may not add to 100 due to rounding.
Note 2: The averages presented in all tables are pure averages of all the data before it was grouped to obtain the frequency tables.

The production rates per hectare for different fruit sizes reproduce the data of Table 2.1 in a different form, shown in Table 2.2. This shows, for example, that though the production rate of size 22 averaged 29 trays per hectare, one percent (or two orchards) were able to produce this sized fruit at a rate of 400 or more trays per hectare.

Table 2.2: Percentage distributions of trays per hectare produced for each fruit size (N = 179 orchards)

Trays/ha	Grade 1: % in each size									Grade 2
	22	25	27	30	33	36	39	42	46	%
0 -	98	89	65	25	10	3	3	17	59	82
200 -	2	9	26	26	15	8	8	24	24	17
400 -	1	2	8	21	19	12	12	25	11	1
600 -	0	1	1	15	21	15	12	18	6	0
800 -	0	0	0	7	16	20	13	10	1	0
1000 -	0	0	0	7	10	18	16	5	1	0
1200 -	0	0	0	0	8	13	15	1	0	0
1400 -	0	0	0	0	1	6	7	1	0	0
1600 -	0	0	0	0	1	4	7	0	0	0
1800 -	0	0	0	0	0	1	6	0	0	0
2000 +	0	0	0	0	0	0	3	0	0	0
Total (%)	101	100	100	101	101	100	102	101	102	100
Av. trays/ha	29.1	86.5	175.9	443.6	671.2	917.4	1049.2	508.6	212.5	83.5

Note 1: The orchard size data (in ha) was obtained from BioGro data and may have some orchards added together if they had the same owner, therefore it may have produced one or two unusual results.
Note 2: Six orchard sizes were not available so any calculations involving production per hectare will usually be based on 179 orchards rather than 185.

2.2.2 Grouping the data into variables of interest

In this section the database has been analysed into different variables that we were advised would be of interest: smaller and larger fruit, fruit obtaining KiwiStart compensation for early picking and the Taste Zespri premium for dry matter and consistency, fruit size, total orchard production and orchard production per hectare, and orchard size. Table 2.3 shows the distributions across all orchards of the first four variables mentioned. Larger fruit are defined as those less than size 36, whereas smaller fruit are those greater than or equal to size 36.

Graph 2.2 compares the two very different distributions of larger and smaller fruit. This graph indicates how some orchards have been able to produce a greater proportion of their production in larger fruit than others. For example, Table 2.3 shows that 19 percent of orchards have been able to produce forty to fifty percent of their production in larger fruit while 12 percent (7 + 4 + 1) have been able to produce fifty percent or more in the larger fruit sizes. However, most orchards are producing the bulk of their production in smaller fruit (e.g., 85 percent (21 + 22 + 27 + 13 + 2) of the orchards produce more than 50 percent of their production in smaller fruit).

Table 2.3: Percentage distributions of percentages of larger and smaller fruit, and percentages gaining KiwiStart compensation and Taste Zespri premiums (N = 185)

% of fruit	% larger fruit	% smaller fruit	KiwiStart %	Taste Zespri %
0 -	2	0	84	51
10 -	17	0	0	1
20 -	29	2	1	0
30 -	21	4	0	2
40 -	19	9	0	2
50 -	7	21	2	4
60 -	4	22	0	4
70 -	1	27	2	3
80 -	0	13	0	5
90 – 100	0	2	12	28
Total (%)	100	100	101	100
Average % of fruit	32.7	65.3	14.6	40.1

Graph 2.2: Comparison of the distributions of larger and smaller fruit

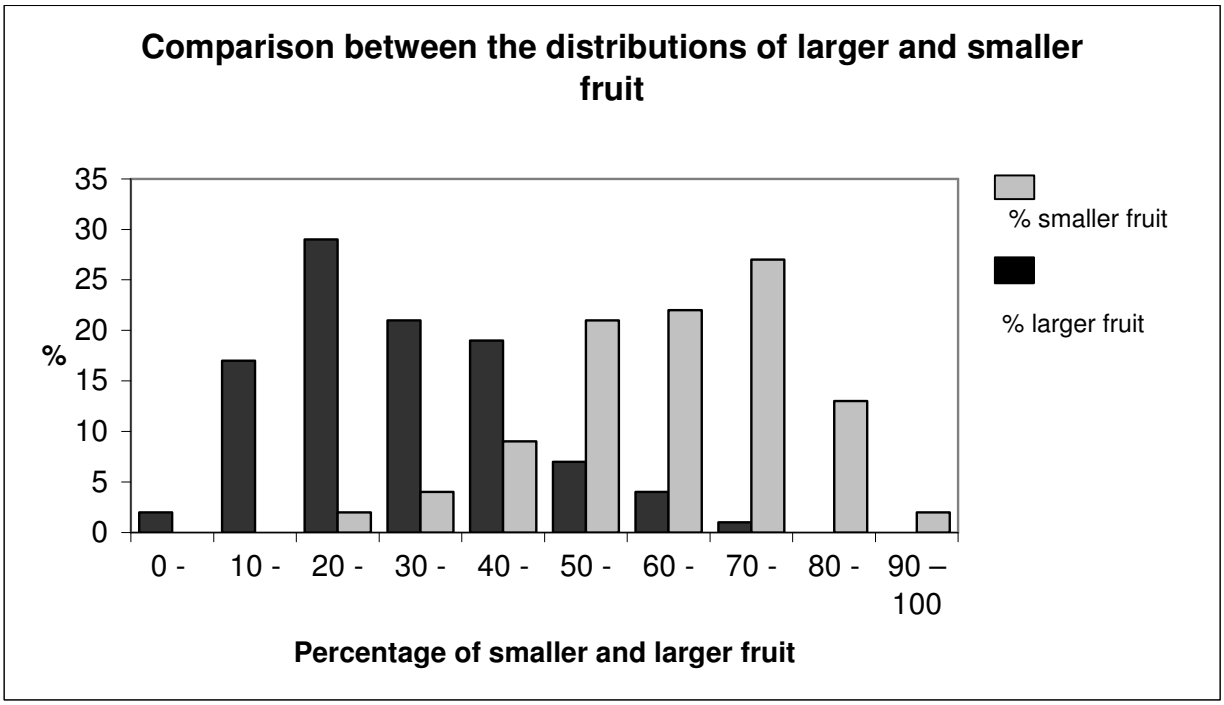
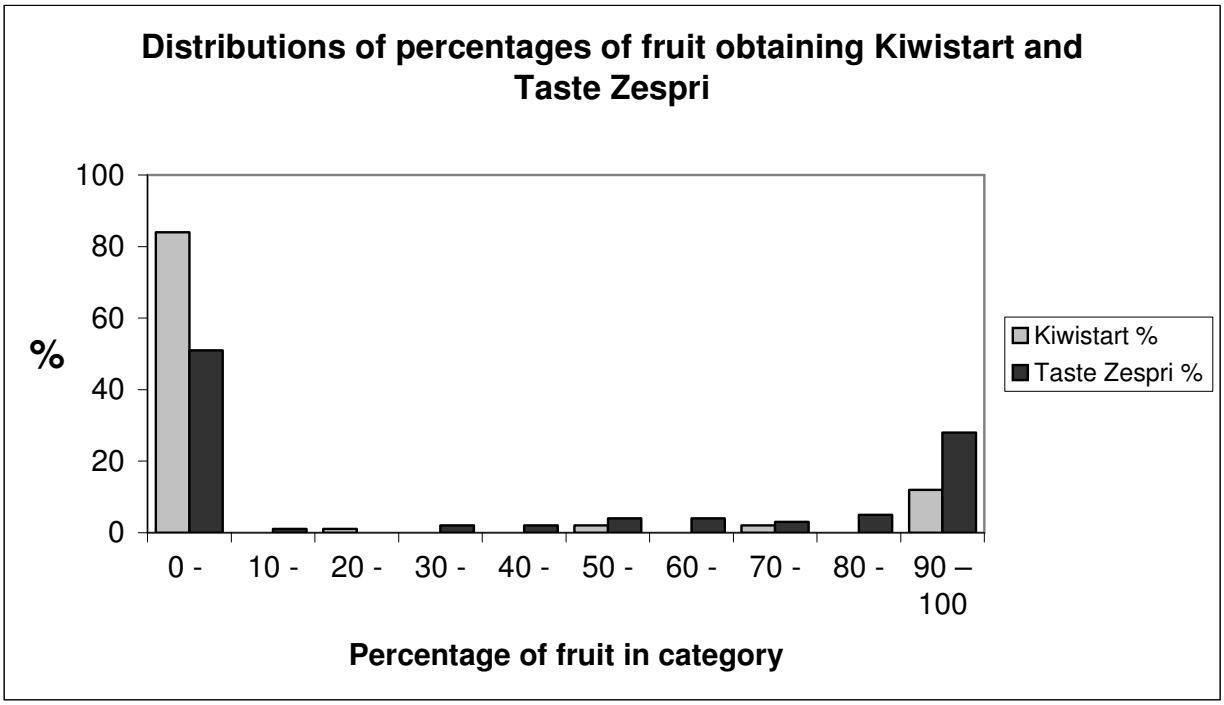


Table 2.3 and Graph 2.3 illustrate the ways in which different orchards gained KiwiStart compensation and Taste Zespri premiums for more or less of their fruit. (From here on for ease of bracketing with Taste Zespri, the KiwiStart compensation will be referred to as a premium.) These analyses show two U-shaped distributions with most orchards either achieving or not achieving these premiums for most of their fruit and a few scattered in between. Eighty-four percent and 51 percent of orchards only had a very small percentage of fruit obtaining these premiums, while 12 and 28 percent respectively obtained them for nearly all their fruit.

Graph 2.3: Percentage distributions of percentages of fruit obtaining KiwiStart compensation and Taste Zespri premiums



A crosstabulation of this data (Table 2.4) reveals that 81 orchards (44 percent) had very few fruit receiving either premium, with only 8 (4 percent) with most of their fruit receiving both. On the other hand 41 orchards (22 percent) had very few fruit receiving KiwiStart but achieved a high proportion of fruit in the Taste Zespri category. These data do not indicate that achieving one premium means an orchard is more likely to achieve the other. (The correlation is not statistically significant.)

Table 2.4: Crosstabulation of orchards obtaining KiwiStart and Taste Zespri premiums

% Taste Zespri % KiwiStart	0 - 10	10 - 90	90 - 100	Total
0 – 10	81 (44%)	34 (18%)	41 (22%)	156 (84%)
10 – 90	1 (1%)	4 (2%)	2 (1%)	7 (4%)
90 – 100	13 (7%)	1 (1%)	8 (4%)	22 (12%)
Total	95 (51%)	39 (21%)	51 (28%)	185 (100%)

Table 2.5 shows the data from Table 2.3 presented in the form of production of trays per hectare. This shows for instance, reading across the top line, that 41 percent of orchards were able to produce larger fruit at a rate of zero to 1,000 trays per hectare, 10 percent produced this amount of smaller fruit, 86 percent produced this amount of KiwiStart and 54 percent produced this amount of Taste Zespri fruit. One and two percent of orchards respectively

were able to produce KiwiStart and Taste Zespri fruit at the rate of 7,000 or more trays per hectare.

Table 2.5: Percentage distributions of trays per hectare of larger and smaller fruit, and trays per hectare gaining KiwiStart and Taste Zespri premiums (N = 179).

Trays/ha of fruit	% larger fruit	% smaller fruit	% KiwiStart	% Taste Zespri
0 -	41	10	86	54
1,000 -	35	19	2	8
2,000 -	18	32	3	10
3,000 -	7	20	3	10
4,000 -	0	13	2	8
5,000 -	0	2	1	5
6,000 -	0	1	1	2
7,000 +	0	1	1	2
Total (%)	101	102	99	99
Average trays/ha	1,406	2,688	590	1,738

Table 2.6: Percentage distribution of average fruit size over orchards (N = 185)

Average size (fruit/tray)	%
31 -	3
32 -	3
33 -	7
34 -	18
35 -	22
36 -	25
37 -	20
38 -	2
39 +	1
Total (%)	101
Average size	35.8

Table 2.6 summarises the fruit size data. As mentioned earlier, the average fruit size was 35.8 fruit per tray but five orchards (3 percent) achieved an average fruit size between 31 and 32 with the lowest being 31.0. The orchard producing the smallest fruit averaged 39.6 fruit per tray.

Table 2.7: Percentage distribution of total trays for each orchard (N = 185)

Total trays/orchard	Percentage (%)
0 -	44
10,000 -	34
20,000 -	14
30,000 -	5
40,000 -	2
50,000 +	2
Total	101
Average trays/orchard	13,796

Table 2.7 provides information about orchard size in terms of their total production. It shows that most orchards were small with 78 percent producing less than 20,000 trays of fruit. Of the four orchards producing more than 50,000 trays the largest was 59,184 trays. This data is then presented in terms of production per hectare in Table 2.8. Orchards ranged in efficiency from 476 trays per hectare to the top five percent which were producing over 7,000 trays per hectare, the most productive being 9,421 trays per hectare. (The latter results are dependent on the accuracy of the orchard size data.)

Table 2.8: Percentage distribution of total trays per hectare for each orchard (N = 179)

Total trays/ha	Percentage (%)
0 -	5
1,000 -	10
2,000 -	13
3,000 -	18
4,000 -	20
5,000 -	23
6,000 -	8
7,000 -	2
8,000 -	2
9,000 +	1
Total	102
Average total trays	4,177

The distribution of the orchard size data (Table 2.9) shows that 55 percent of orchards were less than three hectares in size (canopy cover). The three orchards in the 'over 14ha' category were all greater than 20 hectares in size.

Table 2.9: Percentage distribution of orchard size (in hectares) (N = 179)

Size (ha)	Number	Percentage
0 -	14	8
1 -	39	22
2 -	44	25
3 -	28	16
4 -	20	11
5 -	4	2
6 -	8	5
7 -	7	4
8 -	0	0
9 -	1	1
10 -	2	1
11 -	2	1
12 -	1	1
13 -	6	3
14 +	3	2
Total	179	102
Average	3.8ha	

2.2.3 Geographical features

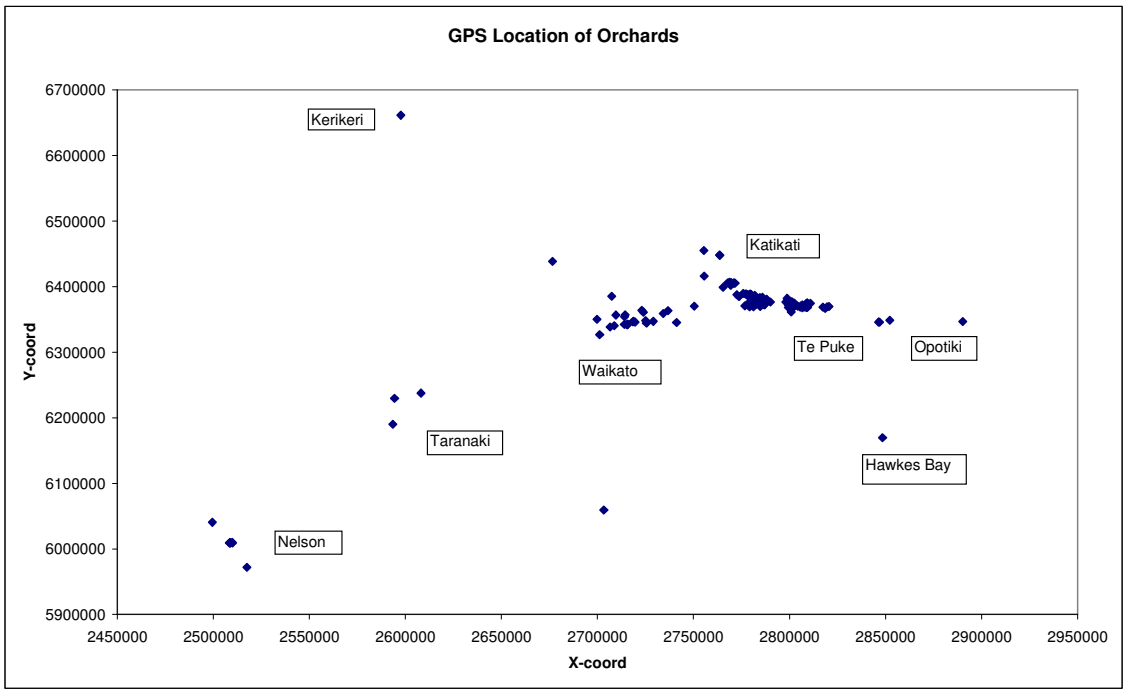
The altitude and GPS coordinates of orchards were available for 169 of the 185 orchards in the database. This data, illustrated in Table 2.10, shows that three orchards (two percent) were above 200m in altitude, with most (51 percent) being within 50m of sea level. As is

already well known, most orchards are on the East coast of the middle of the North Island, mainly around Tauranga and Te Puke (X- coordinates 2750000 or more, and Y-coordinates between 6300000 and 6500000). The locations of the orchards are illustrated in Graph 2.4.

Table 2.10: Percentage distributions of altitude, and GPS X and Y coordinates (N = 169)

Altitude (m)	%	X-coord (GPS)	%	Y-coord (GPS)	%
0 -	51	**2400000 - (West)**	1	**5900000 – (South)**	1
50 -	25	**2500000 -**	6	**6000000 -**	6
100 -	8	**2600000 -**	2	**6200000 -**	86
150 -	14	**2700000 -**	71	**6400000 -**	7
200 +	2	**2800000 + (East)**	21	**6600000+ (North)**	1
Total	100		101		100
Average	70.3m	**Average X-coord**	2761294	**Average Y-coord**	6353289

Graph 2.4: GPS location of orchards



2.2.4 Spray data

The Zespri database contained full details of the spray regimes followed by orchardists with the dates of 'full bloom' in each orchard and spraying dates. This made it possible to consider the number of times orchards were sprayed both before and after full bloom, and this data has been summarised in the following tables. Only mineral oil and Bt spray were used by the majority of orchardists so those are the spray regimes reported on here. Sometimes there was no 'full bloom' date supplied or data was missing so it was assumed as such rather than as indicating there was no spraying regime.

Table 2.11 shows how often orchardists applied mineral oil. The majority used one application before full bloom and two or three after full bloom. This contrasts with the use of Bt spray as shown in Tables 2.12 and 2.13. Only 34 orchardists applied Bt spray before 'full bloom' with most (82 percent) of those spraying less than a month before (Table 2.13).

Forty-five percent of orchardists applied Bt spray three times after full bloom with only two (1 percent) not applying Bt spray at all (Table 2.12).

Table 2.11: Percentage distributions of number of times mineral oil was applied before and after full bloom (N = 182)

No. of times	% Before full bloom	% After full bloom
0	32	8
1	53	14
2	12	34
3	4	34
4	0	11
Total	101	101
Average times	0.9	2.3

Table 2.12: Percentage distributions of Bt Spray Applications (N = 182)

No. of times	% Before full bloom	% After full bloom	% Total applications
0	81	1	1
1	18	10	9
2	1	29	24
3	0	45	41
4	0	14	20
5	0	2	4
6	0	0	1
Total	100	101	100
Average times	0.2	2.7	2.9

Table 2.13: Percentage distribution of number of days Bt applied before full bloom (N = 34)

No. of days before full bloom	%
0 -	35
10 -	32
20 -	15
30 -	9
40 -	6
50 +	3
Total	100
Average	18.5

2.3 Relationships between spray data and other variables of interest

It could be expected that spray regimes may impact on the different production variables. In this section these relationships are analysed. However, it must be understood that where relationships show statistical significance between different spray regimes and their effect on certain production variables, this is not indicative of cause and effect because the data has not been gathered from experiments designed to control intervening and confounding variables. The results have just come from dredging/mining the database to see what of interest might be found. Hence, such relationships could be viewed as indicating possible areas for future research.

There is some consistency between the results but this is more likely to be illustrating that they were drawn from the same database and are calculated from different combinations of the same variables. They are not from independent experiments.

2.3.1 Relationships between the number of applications of mineral oil *before* full bloom and key production variables

Tables 2.14a, b and c show the relationships between the number of applications of mineral oil *before* full bloom and the key production variables presented earlier. Graphs 2.5, 2.6 and 2.7 present some of these relationships graphically. Tables 2.15a, b and c show the relationships between the number of applications of mineral oil *after* full bloom and the key production variables. Graphs 2.8 and 2.9 present some of these relationships graphically.

To interpret the implication of these graphs the tables need to be checked to see if the apparent differences between the number of times the spray was applied are in fact statistically significant. For example, Graphs 2.5 and 2.6 show that two applications of mineral oil *before* 'full bloom' appear to produce a greater percentage of larger fruit (% fruit < size 36), which is also reflected in the lower average fruit size. Checking the means displayed in Table 2.14a shows that the differences between two applications compared with none, one or three are all significant because the superscripts attached to the means are different for two applications as compared to the others. On the other hand looking at Graph 2.5 one could assume that a higher percentage of Taste Zespri fruit appears to be associated with three applications of mineral oil but when checking the table it can be seen that this result does not show any significant differences. This does not mean that this is not so, just that it is not showing up for these results and is possibly associated with the lower number of orchardists who sprayed three times compared with the other number of times mineral oil was applied.

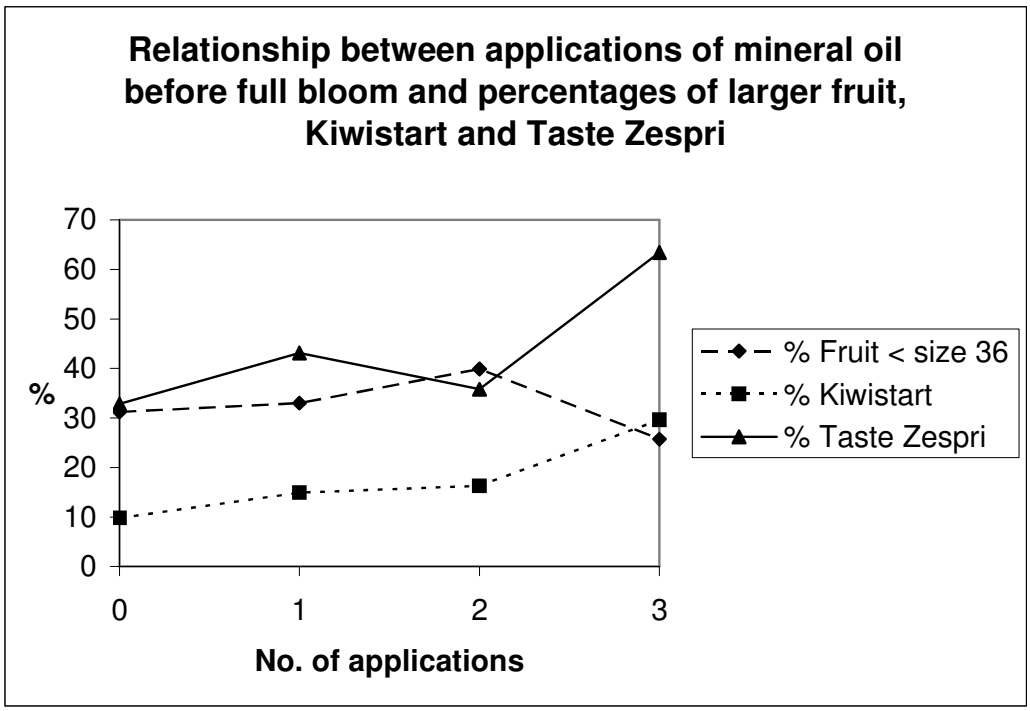
Table 2.14a: Mineral Oil: Number of applications before full bloom and relationships with key production variables

No. of applications	No. in group	Average % larger fruit	Average % Grade 2 fruit	Average % Fruit KiwiStart	Average % Fruit Taste Zespri	Average fruit size
Nil	58	31.2 [b]	2.2	9.8	32.8 [b]	35.9 [b]
1	96	33.0 [b]	1.8	14.9	43.1	35.8 [b]
2	21	39.9 [a]	2.0	16.3	35.8	35.0 [a]
3	7	25.7 [b]	3.0	29.6	63.4 [a]	36.5 [b]
Total/Average	182	32.7	2.0	14.6	40.1	35.8

Note: The superscript indicates which differences between the number of applications are significant at the 5% level (Duncan's Test). In this report these tests are reported as one-tailed tests indicating that one variable is significantly larger than another at the 5% level. The superscripts are interpreted thus: if two numbers bear the same letter in the superscript then they are not significantly different. If the superscripts bear different letters then they show a significant difference between the two levels of spray application, with the largest figure being significantly greater than the smaller at the 5% level of significance. (Those numbers with no superscript are not significantly different from any other.)[1]

[1] Duncan's test is not a test as such but is the notation used to describe the results of paired comparisons in which the numbers in the means are different. It is like doing a t-test but using a pooled estimate of the variance from all the data rather than just from the two groups being compared. (It is usually indicative of a lack of experimental design.) This estimate of the variance comes from an analysis of variance.

Graph 2.5: Relationships between applications of mineral oil before full bloom and larger fruit, KiwiStart and Taste Zespri percentages



Graph 2.6: Relationship between applications of mineral oil before full bloom and average fruit size

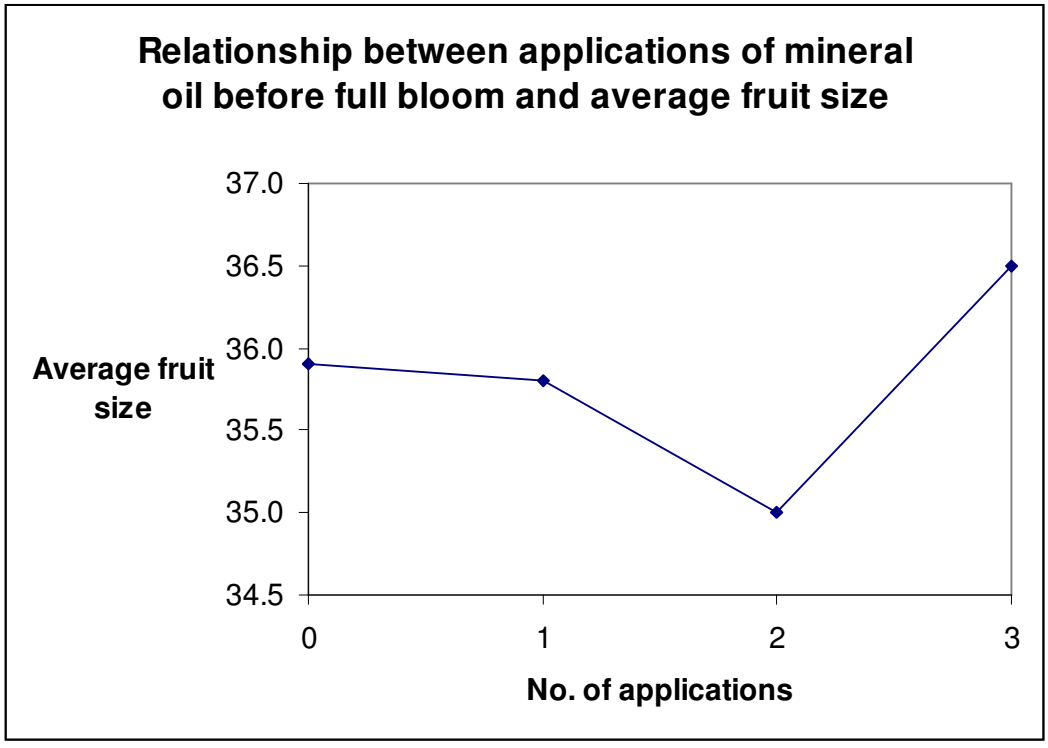


Table 2.14a indicates that the application of mineral oil before full bloom does not appear to impact on the production of KiwiStart or Taste Zespri fruit. Three applications of mineral oil does appear to reduce production overall (trays per hectare) and the production of larger fruit (Graphs 2.5. 2.6 and 2.7) but this result is based on only seven orchards compared with the much larger numbers spraying less than three times. This could show that too many applications of mineral oil pre-bloom may be reducing fruit size and increasing dry matter (DM). (This indicates that the relationship between how many days before full bloom that the oil was applied and these production variables might be worth exploring further.)

Table 2.14b: Mineral Oil cont.: Number of applications before full bloom

No. of applications	No. in group	Average trays/ha	Average trays/ha larger fruit	Average trays/ha grade 2 fruit	Average trays/ha KiwiStart	Average Trays/ha Taste Zespri
0	58	4043 [a]	1286 [a]	94	445	1372
1	91	4302 [a]	1448 [ab]	72	537	1944
2	21	4432 [a]	1826 [c]	98	707	1609
3	7	2701 [b]	678 [d]	87	1260	1687
Total/Average	177	4177	1406	84	590	1738

Table 2.14b supports this indication that three applications of mineral oil before full bloom is having a detrimental effect on production and fruit size.

Graph 2.7: Relationship between applications of mineral oil before full bloom and production

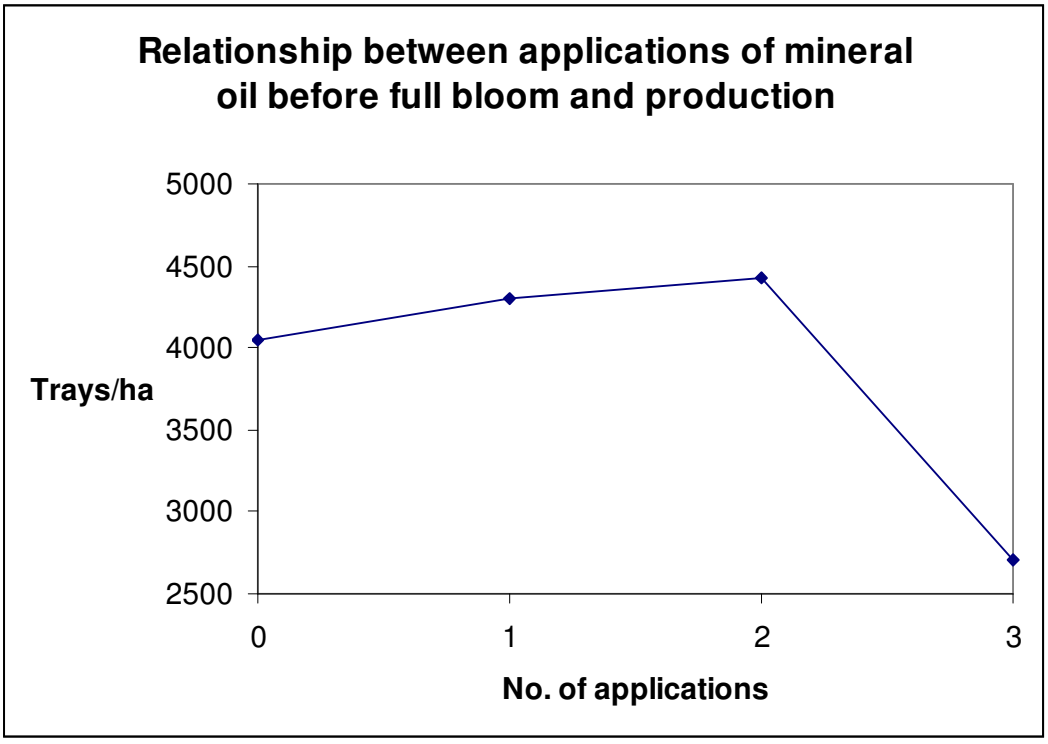


Table 2.14c: Mineral Oil cont.: Number of applications before full bloom

No. of applications	No. in mean	Altitude (m)	X-coordinate	Y-coordinate
0	56	56 [a]	2738005 (West)	6324230 (South)
1	85	81 [b]	2773588	6364415
2	19	67	2771515	6370261
3	7	70	2773852 (East)	6402427 (North)
Total/Average	167	70	2761432	6353198

Table 2.14c relates the applications of mineral oil before full bloom to the location of the orchard. The variances of each group are not homogeneous for the X and Y coordinates so these variables have not been tested for significant differences. However, it does look as if one spray application only of mineral oil before full bloom is more likely further East, than no applications. Similarly, there is more likely to be spray applied before full bloom further north.

2.3.2 Relationships between the number of applications of mineral oil *after* full bloom and key production variables

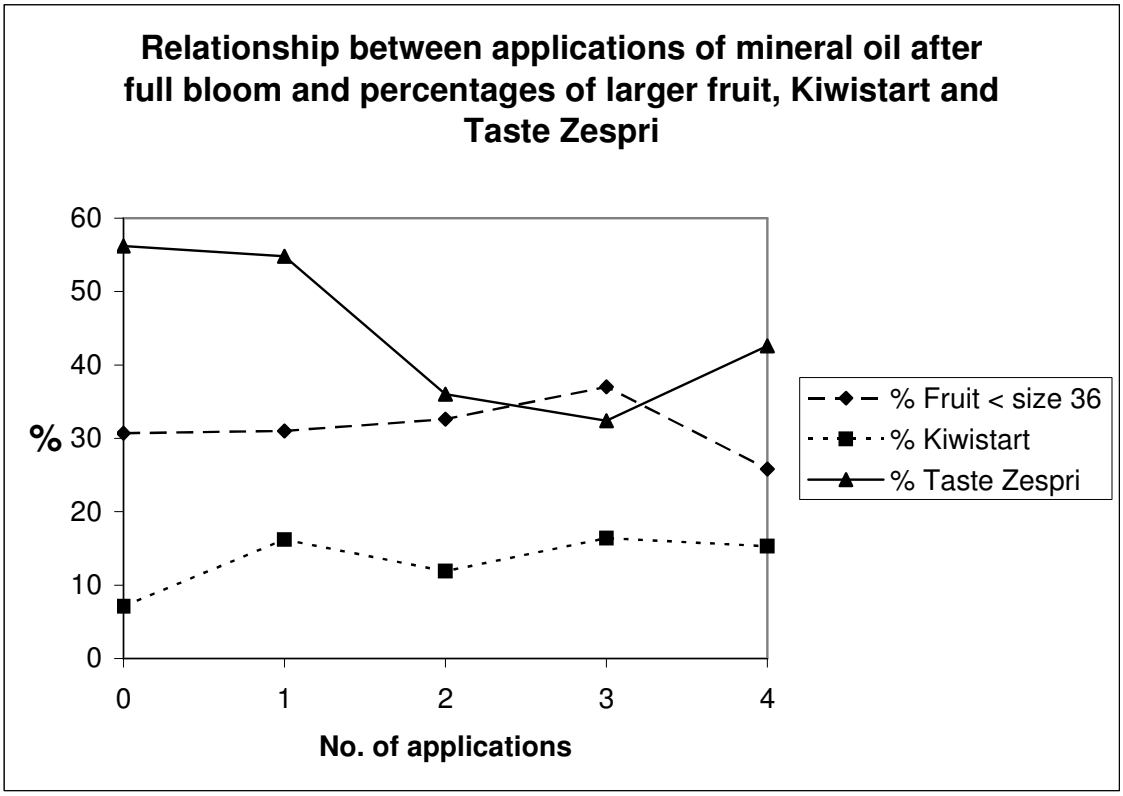
The application of mineral oil *after* full bloom shows up some more interesting patterns. Unfortunately the variances are not homogenous for much of the data, so statements can only be made about apparent trends.[2] For example, there is something happening around the three applications of spray with a greater percentage of bigger fruit being produced. In contrast, the percentage of Taste Zespri fruit produced appears to be greater for none or one spray applications compared with two or three (Table 2.15a, Graphs 2.8 and 2.9). A similar result is appearing in the production (trays per hectare) data, with four spray applications producing a significantly less percentage of larger fruit than two or three applications, and showing significantly more Taste Zespri production per hectare for spraying a single time compared with three times (Table 2.15b). The impact of the number of applications of mineral oil after full bloom on fruit size and Taste Zespri production – percentages and trays per hectare - is evidently worth exploring further.

Table 2.15a: Mineral Oil: Number of applications after full bloom and relationships with key production variables

No. of applications	No. in mean	Average % larger fruit	Average % Grade 2 fruit	Average % fruit KiwiStart	Average % fruit Taste Zespri	Average fruit size
0	14	30.7	4.6	7.1	56.2	35.9
1	26	31.0	1.6	16.2	54.8	36.0
2	61	32.6	1.8	11.9	36.0	35.8
3	61	37.0	1.9	16.4	32.4	35.3
4	20	25.8	1.5	15.3	42.6	36.5
Total/Average	182	32.7	2.0	14.6	40.1	35.8

[2] Another possibility is to analyse variables such as percentage of larger or smaller fruit, percentage of Grade 1 fruit, and percentage of fruit that has not received as KiwiStart or a Taste Zespri premium. These data may be more homogenous than their 'opposites'. Individual t-tests with unequal variances could also be carried out if there was interest in pursuing these analyses.

Graph 2.8: Relationships between applications of mineral oil after full bloom and larger fruit, KiwiStart and Taste Zespri percentages



Graph 2.9: Relationship between applications of mineral oil after full bloom and average fruit size

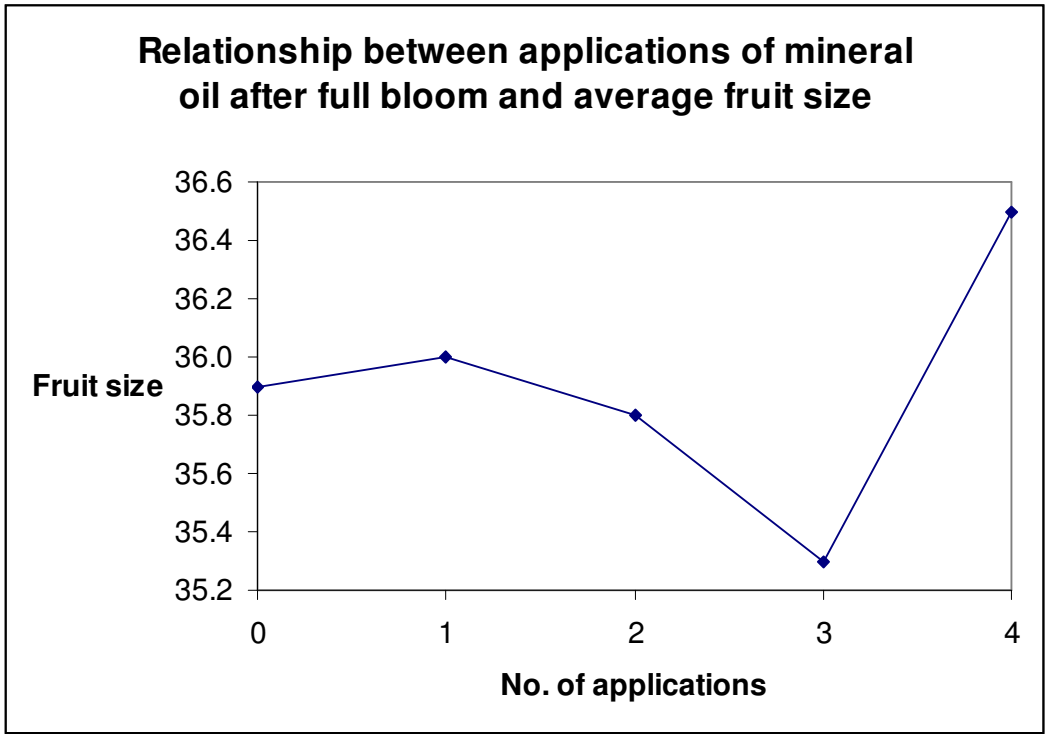


Table 2.15b: Mineral Oil cont.: Number of applications after full bloom

No. of applications	No. in mean	Average trays/ha	Average trays/ha fruit size less than 36	Average trays/ha grade 2 fruit	Average trays/ha KiwiStart	Average Trays/ha Taste Zespri
0	14	3954	1297	185 [b]	60	2480
1	26	3958	1325	68 [a]	582	2414
2	58	4367	1444	80 [a]	653	1527
3	59	4182	1561 [a]	76 [a]	564	1418
4	20	3986	1051 [b]	61 [a]	560	1620
Total/Average	177	4177	1406	84	590	1738

Table 2.15c: Mineral Oil cont.: Number of applications after full bloom

No. of applications	No. in mean	Altitude (m)	X-coordinate	Y-coordinate
0	12	42	2607759 (West)	6112802 (South)
1	24	75	2779895 (East)	6365586
2	58	84	2768012	6373542
3	53	67	2775490	6374210 (North)
4	20	54	2775141	6367893
Total/Average	167	70	2761432	6353198

In Table 2.15c the variances of each group are not homogeneous for the X and Y coordinates or the altitude, so differences between these the number of spray applications have not been explored. However, it does look as if mineral oil is more likely to be applied after full bloom the further west or north the orchard.

2.3.3 Relationships between the number of applications of Bt spray and location

It was decided by the advisory group that an analysis of the relationships between Bt spray and the key production variables were meaningless because there was no biological explanation for how Bt spray could affect them. However, the table relating the use of Bt spray to location was considered to be useful.

Table 2.16: Number of applications of Bt spray after full bloom

No. of applications	No. in mean	Altitude (m)	X-coordinate	Y-coordinate
0	2	95	2652032 (West)	6172375 (South)
1	14	37 [b]	2670643	6203815
2	49	62	2752504	6361500
3	75	76 [a]	2782072	6377146 (North)
4	23	84 [a]	2772441	6360507
5	4	111 [a]	2792925 (East)	6373709
Total/Average	167	70	2761432	6353198

In Table 2.16 the relationship between the number of times Bt spray is applied and the location of the orchards is summarised. It would appear that the higher in altitude an orchard is the more times it is likely to have Bt spray applied. The variances of each group are not homogeneous for the X and Y coordinates so as before, no testing has been done for difference between different numbers of times of spraying. However, it does look as if two

or more applications of Bt spray after full bloom are more likely further east and north, than one or nil applications.

2.4 The limitations of geography

In this section the scattergrams of the different relationships between some of the production variables and the independent variables altitude, and the GPS coordinates are examined to see what limitations height above sea level and north-south, and east-west locations might impose on Hayward Green production and the attainment of premiums.

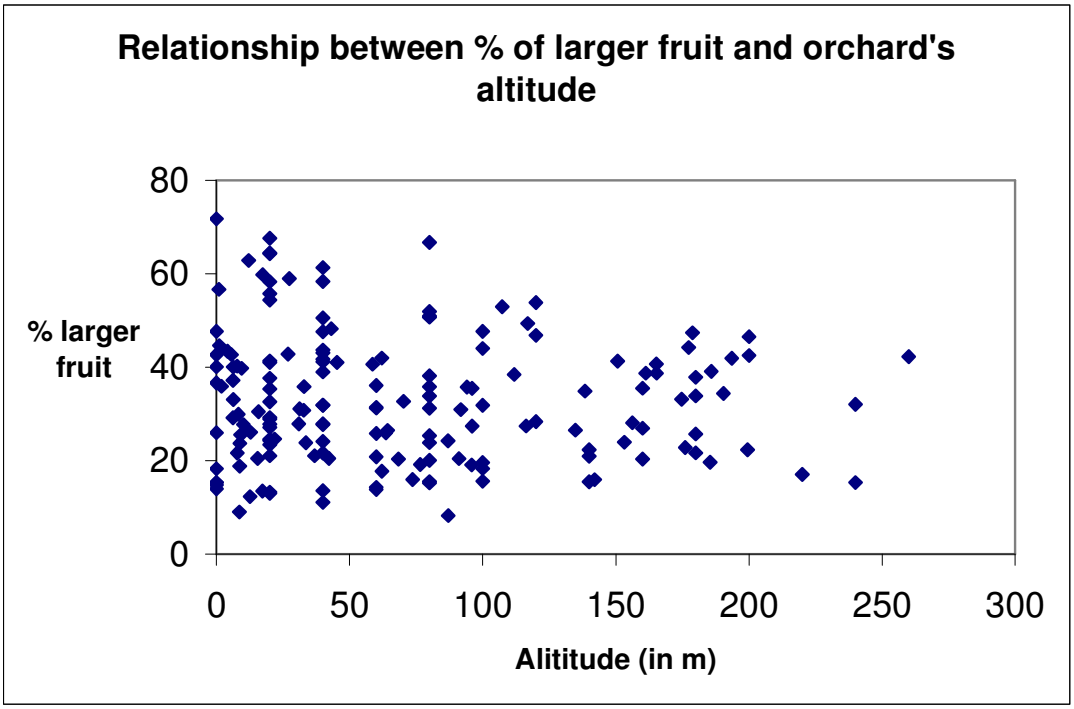
2.4.1 Altitude

Graph 2.10 suggests that the higher the altitude of the orchard the lower the potential for producing a high percentage of fruit of a larger size. From the next graph, Graph 2.11, it looks as if it is difficult to produce fruit of an average size less than 33 above 100m in altitude. However, altitude does not appear to affect production of fruit per hectare, as Graph 2.12 demonstrates.

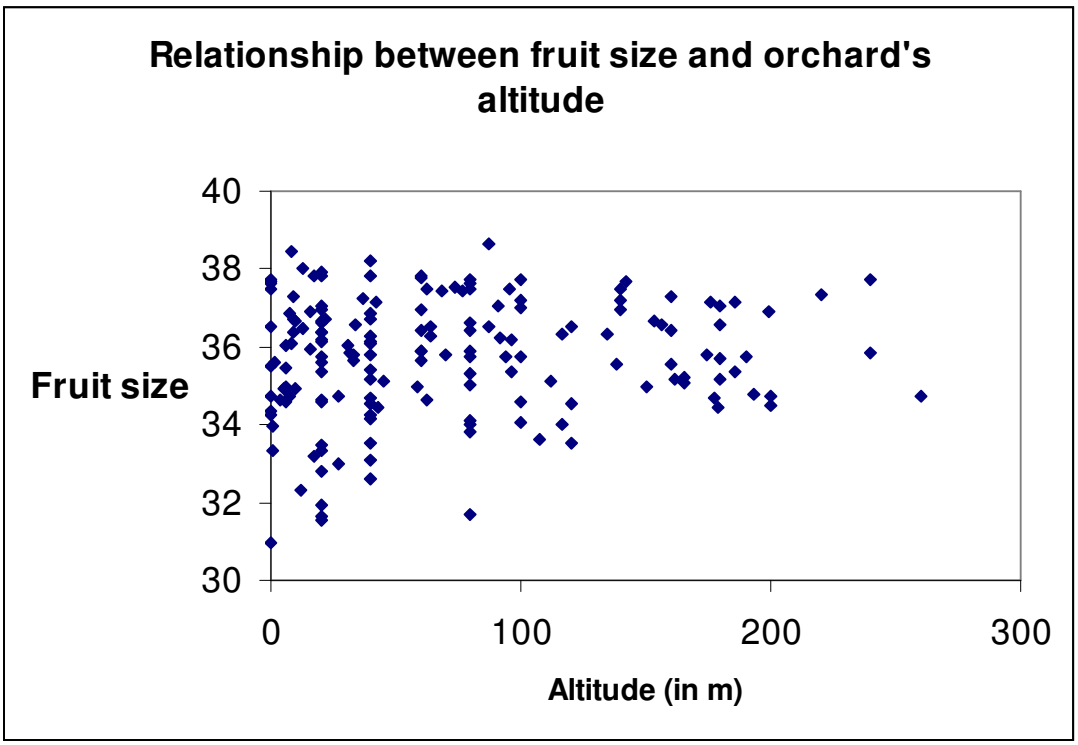
The potential to produce early fruit for the KiwiStart compensation is obviously affected by altitude with no orchards above 140m achieving this. However, it is worth noting that one Bay of Plenty orchard at 140m did gain it (Graph 2.13). Note that most orchards above 140m were in the Bay of Plenty area and probably inland from Tauranga (X-coordinates 2780000 to 2800000, Y-coordinates 6360000 to 6370000).

The potential to achieve a Taste Zespri premium does not appear to be affected by altitude, except possibly for orchards above 200m. However with only three above this height it is difficult to tell (Graph 2.14).

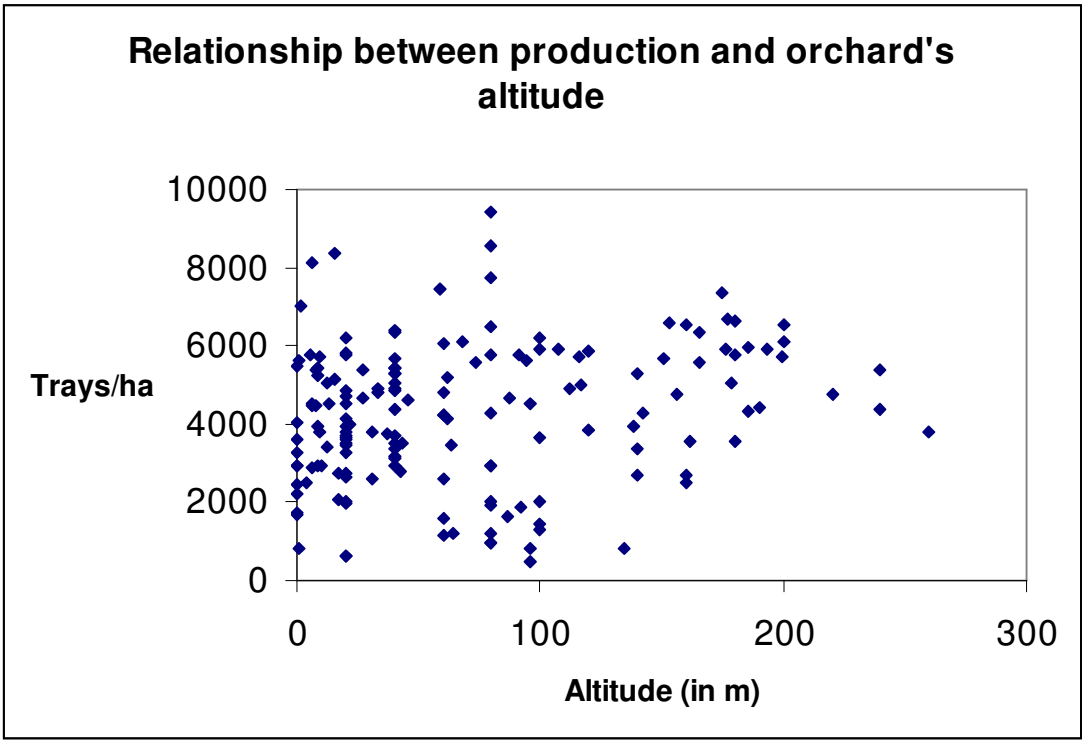
Graph 2.10: Relationship between percentage of larger fruit and orchard's altitude



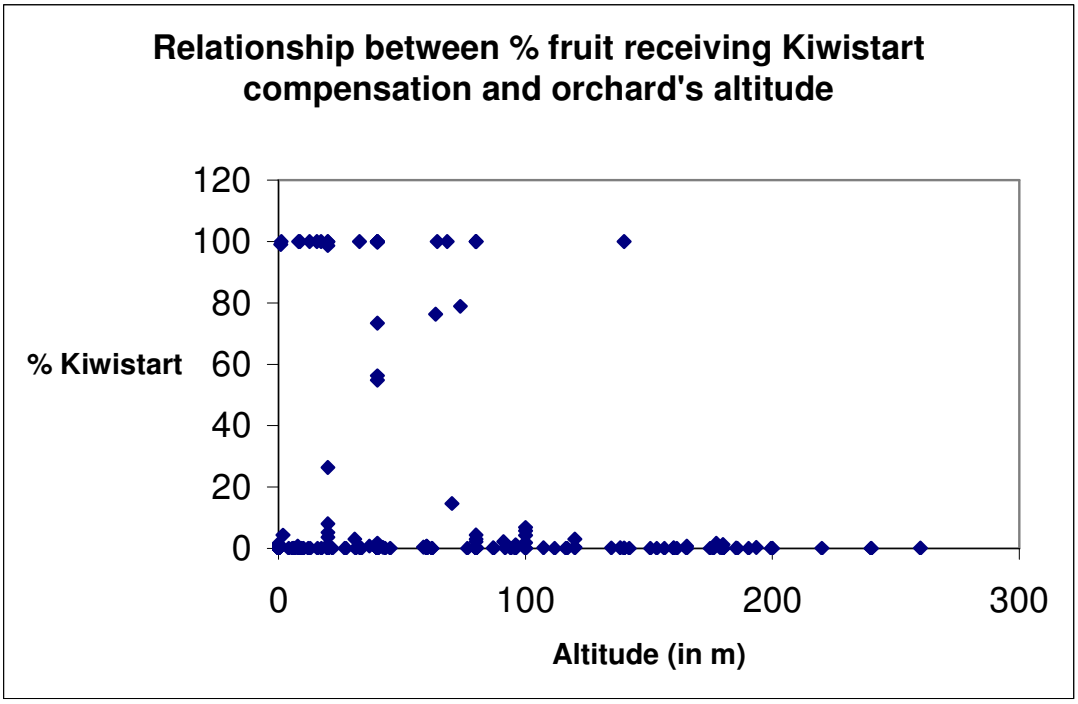
Graph 2.11: Relationship between average fruit size and orchard's altitude



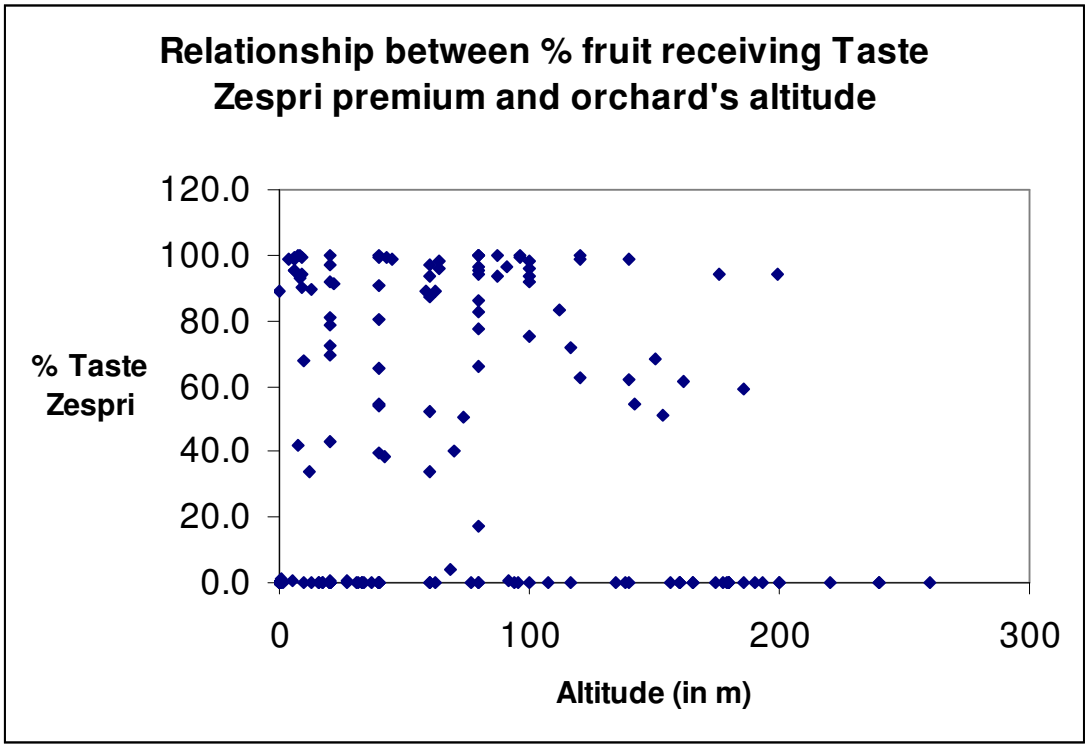
Graph 2.12: Relationship between production and orchard's altitude



Graph 2.13: Relationship between percentage of fruit receiving KiwiStart compensation and orchard's altitude



Graph 2.14: Relationship between percentage of fruit receiving Taste Zespri premium and orchard's altitude

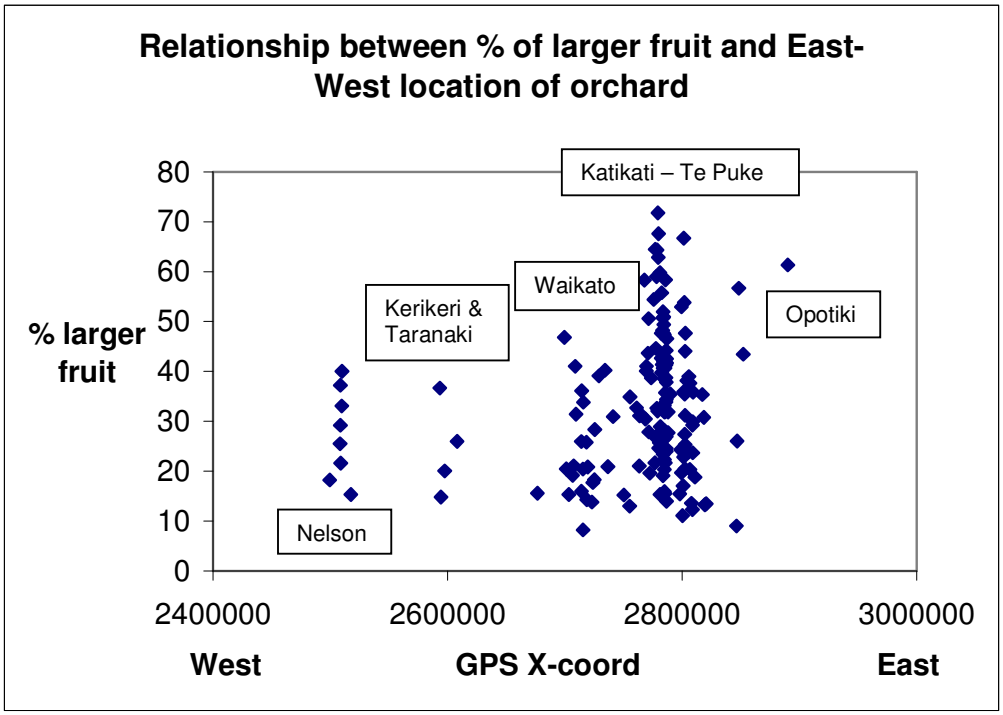


2.4.2 The impact of eastern or western locations

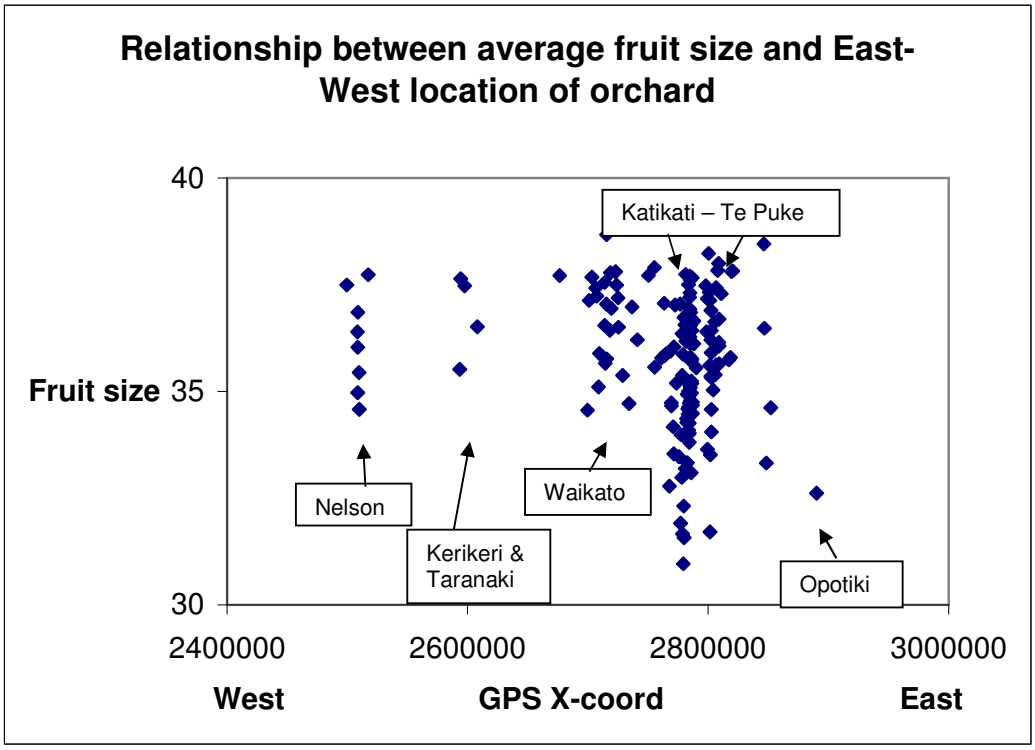
Graphs 2.15 and 2.16 indicate that the potential to grow a greater percentage of larger fruit and to grow larger fruit appears to be limited the further west an orchard is located, with GPS X-coordinates less than 2750000 being unlikely to produce fruit of average size less than 34.6, or have more than 50 percent of production being larger fruit. However, the east-west location seems unlikely to affect the production potential (trays per hectare) of an orchard (see Graph 2.17).

It would appear that orchards in the west (less than 2700000 on the GPS X-coordinate) are unlikely to gain a KiwiStart premium (Graph 2.18), but that this does not affect the potential for producing Taste Zespri fruit (Graph 2.19).

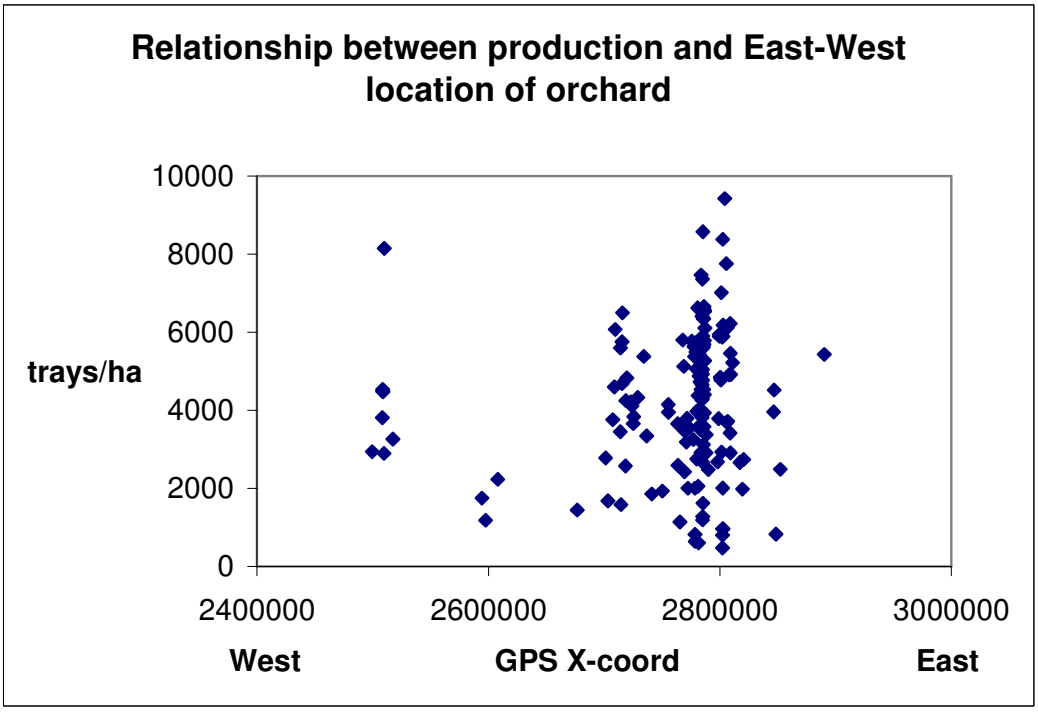
Graph 2.15: Relationship between percentage of larger fruit and East-West location of orchard



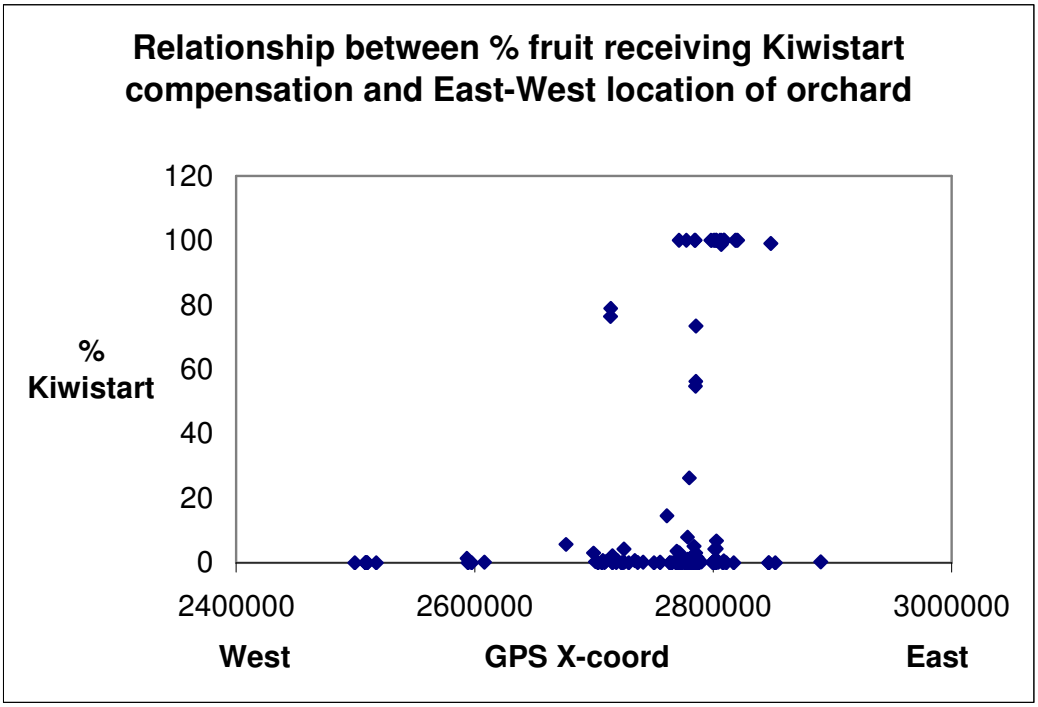
Graph 2.16: Relationship between average fruit size and East-West location of orchard



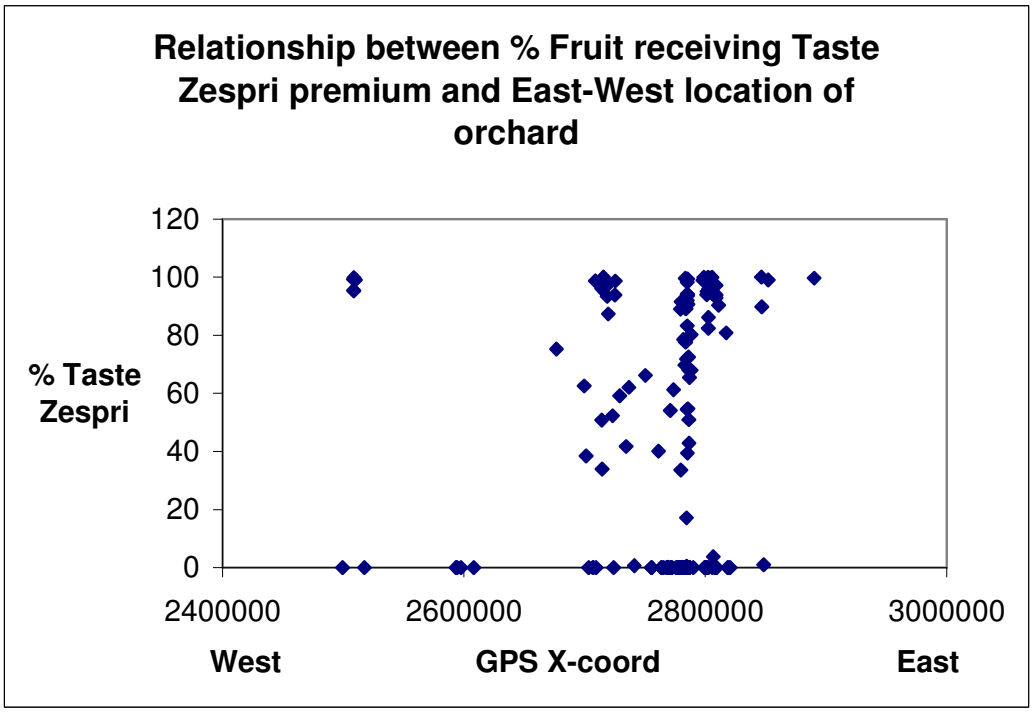
Graph 2.17: Relationship between production and East-West location of orchard



Graph 2.18: Relationship between percentage of fruit receiving KiwiStart compensation and East-West location of orchard



Graph 2.19: Relationship between percentage of fruit receiving Taste Zespri premium and East-West location of orchard

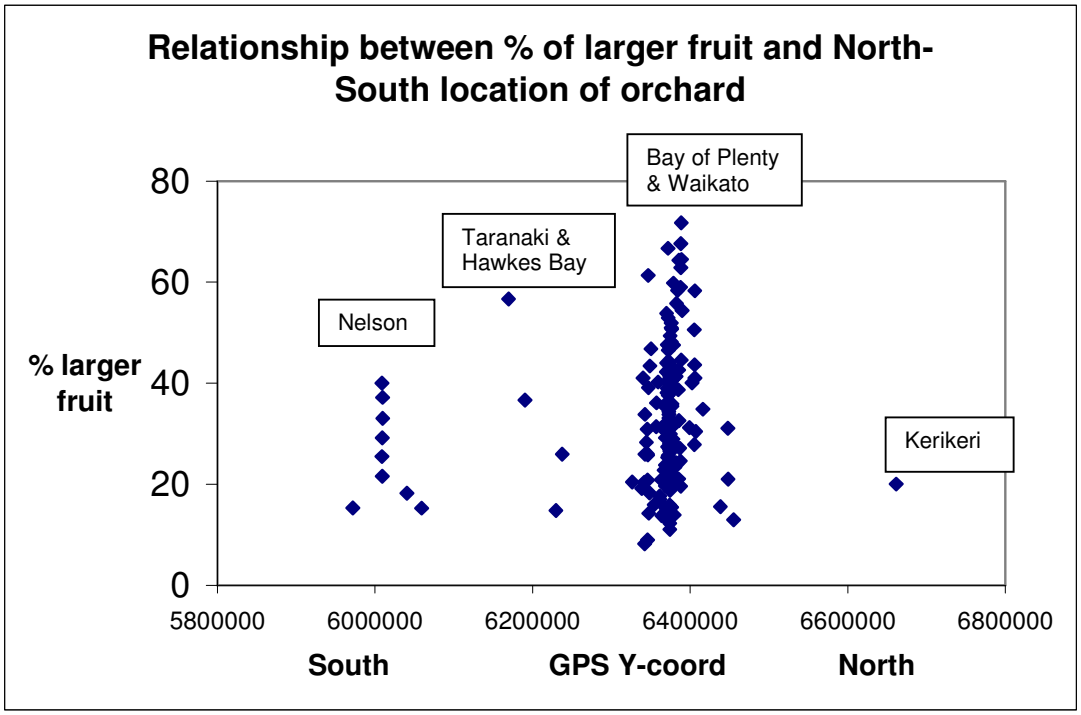


2.4.3 The impact of northern or southern locations

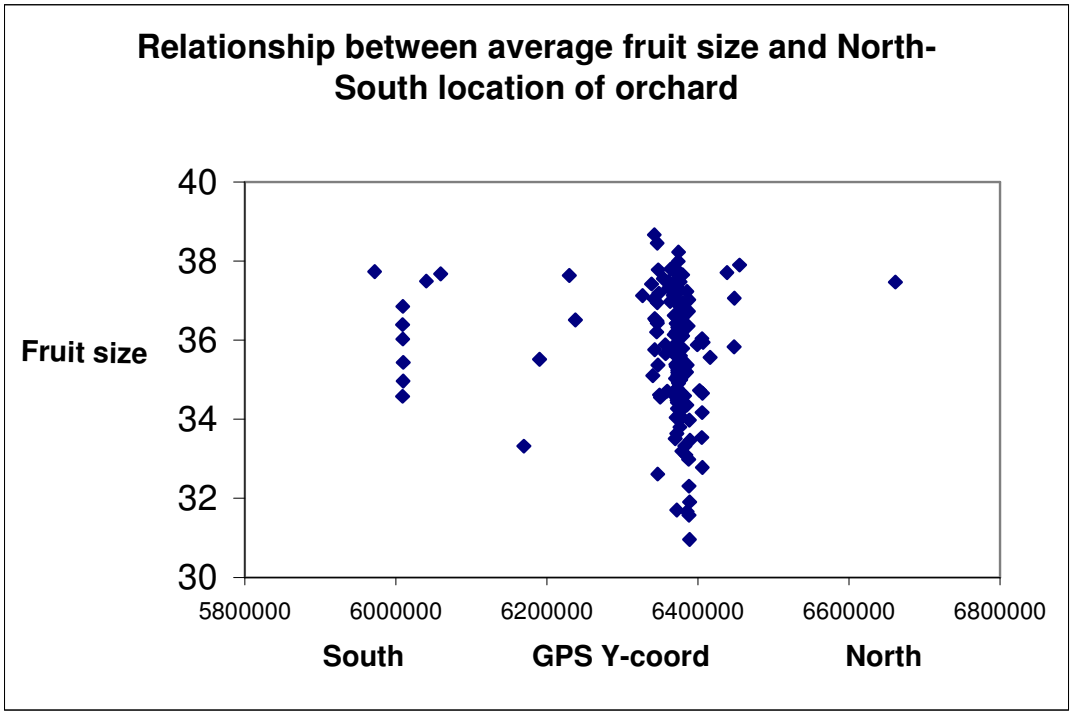
Southern locations (with a GPS y-coordinate less than 6100000) would appear to find it difficult to produce more than 40 percent of their fruit in larger sizes (Graph 2.20), or to obtain an average fruit size less than 34.6 (Graph 2.21). On the other hand, it is difficult to tell whether a southern location inhibits production potential because of the one southern orchard producing well (Graph 2.22). (It may be that this is an outlier through having an inaccurate orchard size.)

The most southern orchards appear unlikely to obtain a KiwiStart premium (Graph 2.23) but this does not appear to affect their Taste Zespri potential as two of the southern most orchards achieved this with nearly 100 percent of their fruit (Graph 2.24).

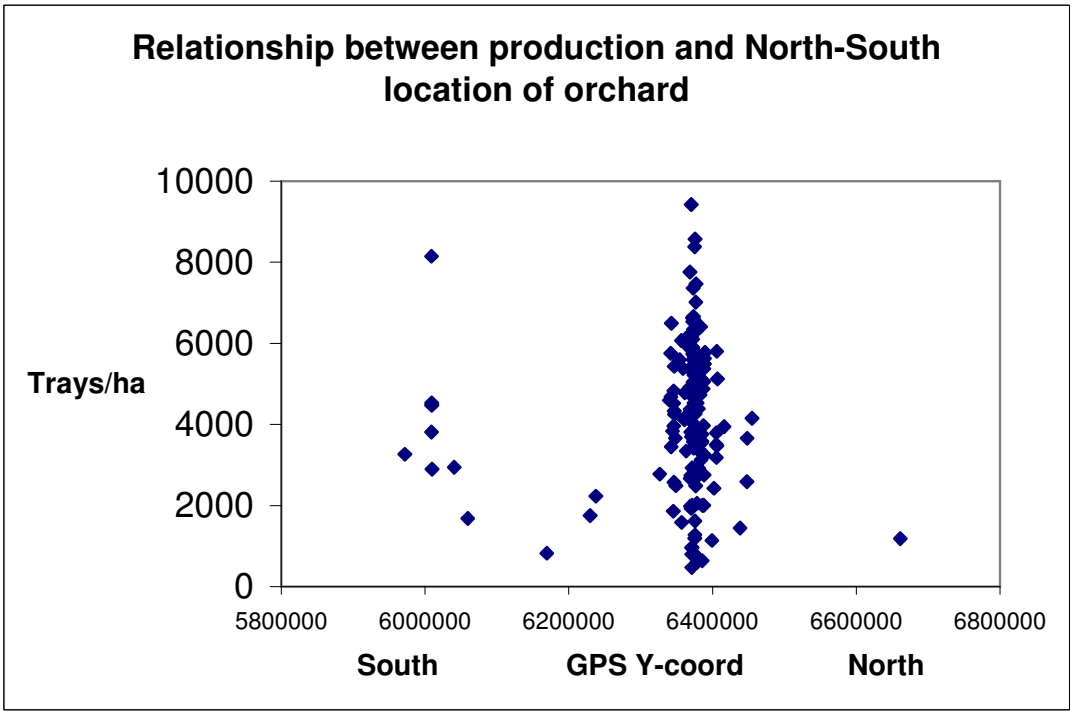
Graph 2.20: Relationship between percentage of larger fruit and North-South location of orchard



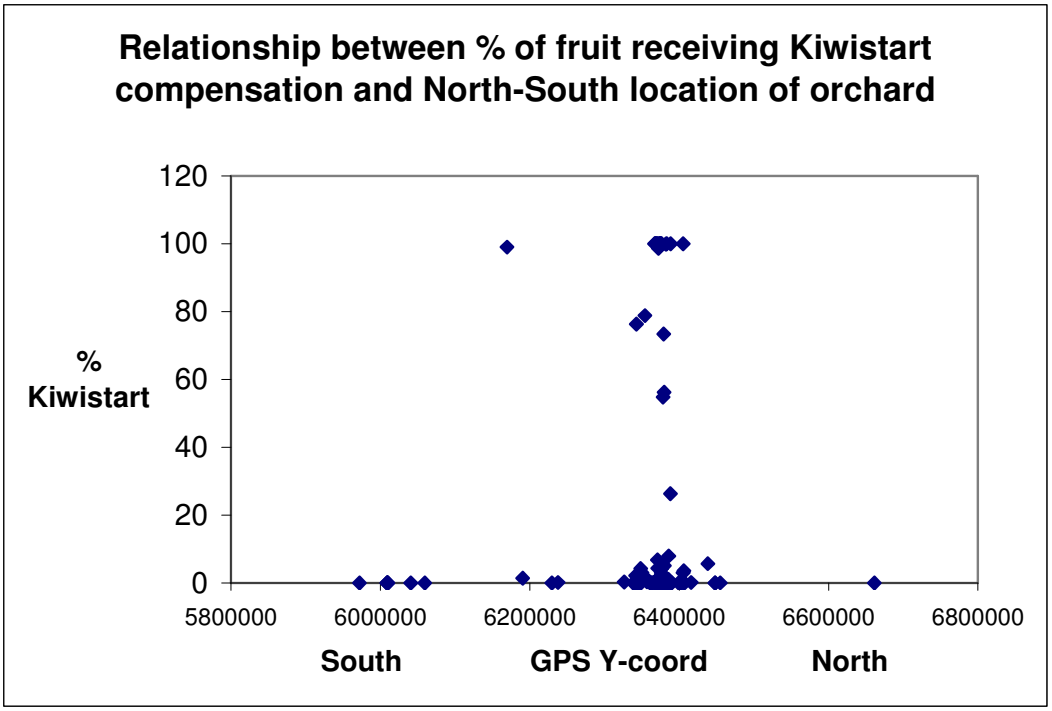
Graph 2.21: Relationship between average fruit size and North-South location of orchard



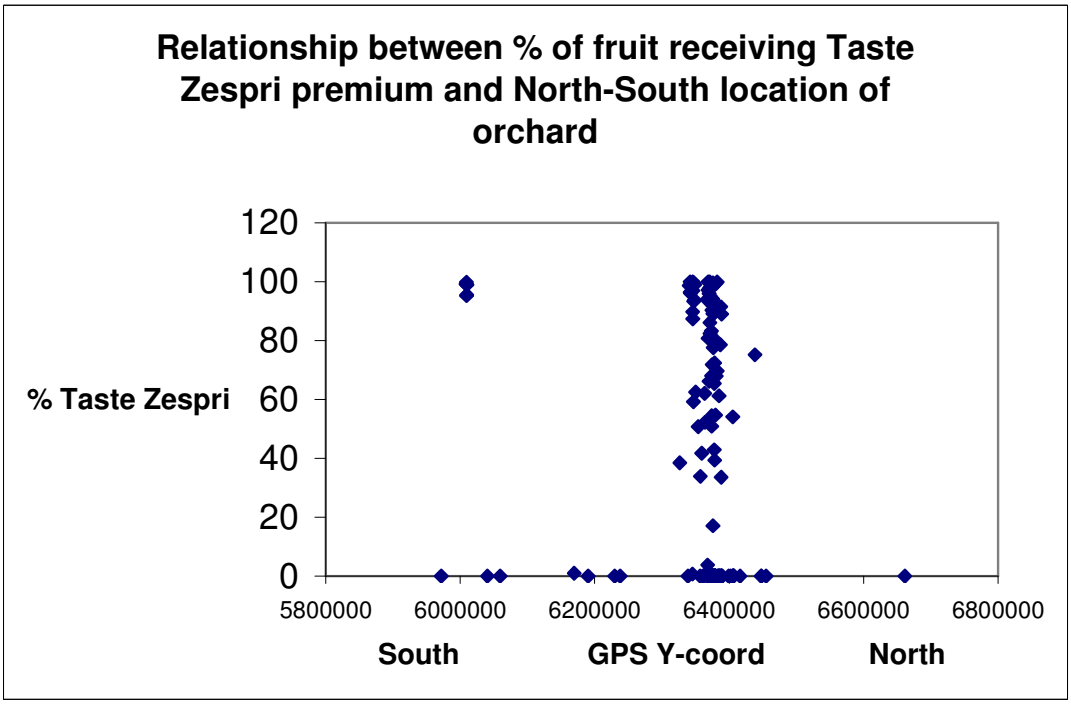
Graph 2.22: Relationship between production and North-South location of orchard



Graph 2.23: Relationship between percentage of fruit receiving KiwiStart compensation and North-South location of orchard



Graph 2.24: Relationship between percentage of fruit receiving Taste Zespri premium and North-South location of orchard



2.5 Relationships between variables of interest

Table 2.17 shows the correlations or the strength of the relationships between the key variables. As would be expected there are high correlations between some of the variables to do with production. For example, the 'percentage of larger fruit' is obviously correlated with

the 'percentage of smaller fruit', and the corresponding transformation of this into trays per hectare, which will be related but not quite so much because of the differing efficiencies of orchards of different sizes.

Table 2.17: Correlations of major variables of interest

Variable		% larger fruit	% smaller fruit	% Kiwi Start	% Taste Zespri	Av. fruit size	Trays/ha	Trays/ha larger fruit	Trays/ha smaller fruit	Trays/ha KiwiStart	Trays/ha Taste Zespri
% larger fruit	R	1.00	-0.98	-0.14	-0.07	-0.99**	0.13	.073**	-0.34**	-0.17*	-0.03
	p	.	0.00	0.07	0.38	0.00	0.09	0.00	0.00	0.02	0.70
	N	185	185	185	185	185	179	179	179	179	179
% smaller fruit	R		1.00	0.11	0.03	0.99**	-0.12	-0.72**	0.35**	0.14	0.00
	p		.	0.15	0.735	.000	.127	.000	.000	.061	.971
	N		185	185	185	185	179	179	179	179	179
% Kiwi Start	R			1.00	0.03	0.11	-0.04	-0.16*	0.06	0.88**	0.00
	p			.	0.68	0.14	0.73	0.03	0.42	0.00	0.98
	N			185	185	185	179	179	179	179	179
% Taste Zespri	R				1.000	0.04	0.03	-0.04	0.05	0.02	0.85**
	p				.	0.56	0.72	0.61	0.52	0.83	0.00
	N				185	185	179	179	179	179	179
Average fruit size	R					1.00	-0.12	-0.71**	0.35**	0.15*	0.01
	p					.	0.12	0.00	0.00	0.04	0.85
	N					185	179	179	179	179	179
Trays/ha	R						1.00	0.73**	0.87**	0.18*	0.39**
	p						.	0.00	0.00	0.02	0.00
	N						179	179	179	179	179
Trays/ha larger fruit	R							1.00	0.30**	-0.06	0.23**
	p							.	0.00	0.45	0.00
	N							179	179	179	179
Trays/ha smaller fruit	R								1.00	0.27**	0.36**
	p								.	0.00	0.00
	N								179	179	179
Trays/ha KiwiStart	R									1.00	0.06
	p									.	0.41
	N									179	179
Trays/ha Taste Zespri	R										1.00
	p										.
	N										179

Note 1: R is Pearson's correlation coefficient
Note 2: 'p' is the probability of getting this result by chance.
Note 3: N is number of paired observations in analysis.
Note 4: ** marks a correlation coefficient that is highly significant ($p < 0.01$)
Note 5: * marks a correlation coefficient that is significant ($p < 0.05$)

An obvious question was whether increasing the size of fruit increased production. When graphs were drawn and correlations considered of the relationships between the average fruit size or the percentages of larger fruit and orchard production in trays per hectare there appeared to be no obvious relationships. In fact the orchards with the higher production

levels appeared to be producing fruit of the overall average size with overall average percentages of larger fruit.

Similarly, it could be asked if fruit size was related to achievement of a Taste Zespri premium. This also appeared to be unrelated.

Trays per hectare of fruit obtaining KiwiStart compensation correlated negatively with the percentage of larger fruit and more strongly and positively with the production (trays per hectare) of smaller fruit. This is probably because KiwiStart fruit are picked early and so likely to be smaller. Further regression analyses could be done correcting these variables of interest for such independent variables as altitude and the GPS coordinates.

Orchard size (either size in hectares or 'total trays produced') did not appear to be related to more efficient production or more successful production of particular fruit qualities with a few exceptions. The biggest orchards in terms of 'total trays' seemed less likely to get KiwiStart compensation but this did not show up when 'size in hectares' was used. On the other hand the top three orchards in terms of 'size in hectares' gained a high Taste Zespri percentage but this did not show up when compared with 'total trays'. When the efficiency of production in trays per hectare was compared with 'size in hectares' the larger orchards were at the lower efficiency end of the spectrum. There is no consistency either with the top ten orchards for 'larger fruit', trays per hectare, KiwiStart or Taste Zespri premium percentages, all being different, indicating that doing well in one area does not necessarily mean doing well in another.

The next chapter goes on to present the results for the Hort16A database.

Chapter 3
Results of the Analyses of the Organic Hort16A Kiwi Gold Data

3.1 Introduction

In this chapter the results from analyses of the 35 orchards in the organic Hort16A database are presented. First there are summaries of the variables in the form of frequency tables. This is followed by a consideration of the relationships between some of these variables and the spraying regimes, and a look at some correlations between these variables of interest. The chapter concludes with analyses of the limitations imposed by geographical location.

3.2 Summary of variables

The summaries presented here in frequency tables are of fruit size in various configurations, KiwiStart and Taste Zespri percentages and production, total trays produced per orchard, and production per hectare, orchards size, geographical features and spray data. The data for Hort16A has been placed in similar but fewer tables as those for Hayward Green. No graphs have been provided. If there is a need for more data to be visually displayed or presented in tables as for Hayward Green this could be arranged under a further contract.

3.2.1 Fruit size profiles

There is an increasing percentage of fruit in each fruit size till a maximum range is reached at 36 fruit per tray, and it rapidly declined until 42 fruit per tray (Table 3.1). The same data are presented as trays per hectare of fruit in each size in Table 3.2 which shows that most fruit (31 percent) is produced in the size 36 class, while Table 3.3 shows there is an average of 30 percent of the production in larger fruit (i.e., less than size 36).

The percentages of fruit receiving KiwiStart and Taste Zespri premiums follow U-shaped distributions with orchards mainly receiving or not receiving premiums for all of their fruit, with very few scattered between (27 percent for KiwiStart and 29 percent for Taste Zespri). For example, 43 percent of orchards received a KiwiStart premium for less than ten percent of their fruit, while 31 percent received it for more than 90 to 100 percent of their fruit (Table 3.3). The corresponding figures for Taste Zespri are 34 percent for less than ten percent of fruit and 37 percent for 90 to 100 percent.

The average fruit size over all orchards is 35.3 fruit per tray with one orchard (3 percent) recording an average fruit size of 31.7 (Table 3.4).

Table 3.1: Percentage distributions of percentages of fruit in each size (N = 35)

% in this fruit size	Grade 1								Grade 2
	22	25	27	30	33	36	39	42	
0 -	88	77	26	3	0	0	0	9	40
2 -	9	14	26	11	0	0	0	6	0
4 -	3	6	14	14	0	0	0	9	3
6 -	0	0	23	26	3	0	6	20	9
8 -	0	3	6	12	3	0	3	9	6
10 -	0	0	3	11	3	0	11	17	11
12 -	0	0	3	14	14	0	17	3	11
14 -	0	0	0	9	9	0	23	9	3
16 -	0	0	0	0	17	0	17	6	3
18 -	0	0	0	0	11	3	3	6	0
20 -	0	0	0	0	9	0	3	3	6
22 -	0	0	0	0	20	6	12	3	3
24 -	0	0	0	0	6	6	3	3	3
26 -	0	0	0	0	3	17	0	0	0
28 -	0	0	0	0	0	20	3	0	3
30 -	0	0	0	0	3	9	0	0	0
32 -	0	0	0	0	0	20	0	0	0
34 -	0	0	0	0	0	9	0	0	0
36 -	0	0	0	0	0	3	0	0	0
38 -	0	0	0	0	0	3	0	0	0
40 +	0	0	0	0	0	6	0	0	0
Total (%)	100	100	101	100	101	102	101	103	101
Average %	0.8	1.5	4.8	8.3	18.6	30.9	15.8	10.6	8.4

Note: The averages presented in all tables are pure averages of all the data before it was grouped to obtain the frequency tables.

Table 3.2: Percentage distributions of trays per hectare produced for each fruit size (N = 34)

Trays/ha	Grade 1								Grade 2
	22	25	27	30	33	36	39	42	
0 -	97	97	62	44	21	3	18	41	50
200 -	3	3	24	24	18	15	24	15	15
400 -	0	0	15	15	9	15	15	12	6
600 -	0	0	0	18	15	12	15	12	15
800 -	0	0	0	0	9	9	12	9	9
1000 -	0	0	0	0	18	6	9	0	3
1200 -	0	0	0	0	6	6	0	6	3
1400 +	0	0	0	0	6	35	9	6	0
Total (%)	100	100	101	101	102	101	102	101	101
Average trays/ha	31	58	174	302	677	1158	627	497	315

Note: The orchard size data (in ha) was obtained from BioGro data and some other source so may have some orchards added together if they had the same owner.

Table 3.3: Percentage distributions of percentages of larger and smaller fruit, and percentages gaining KiwiStart and Taste Zespri premiums (N = 35).

% of fruit	% larger fruit	% smaller fruit	KiwiStart %	Taste Zespri %
0 -	0	0	43	34
10 -	14	0	6	3
20 -	29	0	3	0
30 -	20	6	0	6
40 -	26	17	6	3
50 -	9	40	0	0
60 -	3	23	3	0
70 -	0	11	6	6
80 -	0	3	3	11
90 +	0	0	31	37
Total	101	100	101	100
Average %	34.2	57.4	44.4	54.0

Table 3.4: Percentage distribution of average fruit size over orchards (N = 35)

Average size (fruit/tray)	%
31 -	3
32 -	3
33 -	11
34 -	26
35 -	23
36 -	20
37 - 38	14
Total	100
Average size	35.3

Most orchards (74 percent) produced less than 10,000 trays of Hort16A fruit, however, the two largest orchards produced over 50,000 trays (Table 3.5). When this is converted to trays per hectare (Table 3.6), the most efficient orchard produced 9,739 trays per hectare while the least efficient produced 526 trays per hectare. Seventy-two percent of orchards were producing less than 5,000 trays per hectare.

Table 3.5: Percentage distribution of total trays for each orchard (N = 35)

Total trays/orchard	Percentage (%)
0 -	74
10,000 -	17
20,000 -	3
30,000 -	0
40,000 -	0
50,000 +	6
Total	100
Average total trays	8,300

Table 3.6: Percentage distribution of total trays per hectare for each orchard (N = 34)

Total trays/ha	Percentage (%)
0 -	12
1,000 -	24
2,000 -	12
3,000 -	6
4,000 -	18
5,000 -	6
6,000 -	12
7,000 -	6
8,000 -	3
9,000 +	3
Total	103
Average trays/ha	3,847

Sixty-seven percent of Hort16A orchards were less than two hectares in size (Table 3.7).

Table 3.7: Percentage distribution of orchard size (in ha)

Size (ha)	Number	Percentage
0 -	12	35
1 -	11	32
2 -	4	12
3 -	3	9
4 -	2	6
5 +	2	6
Total	34	100
Average	1.9 ha	

3.2.2 Geographical features

The Hort16A orchards appear to be all in the Bay of Plenty and Waikato regions (Table 3.9) with most (80 percent) less than one hundred metres above sea level (Table 3.8). However, one orchard was at 244m.

Table 3.8: Percentage distribution of height above sea level (in metres) (N = 35)

Altitude (m)	%
0 -	31
50 -	49
100 -	9
150 -	9
200 +	3
Total	101
Average	79.4m

Table 3.9: Percentage distribution of GPS X-coordinates and Y-coordinates (N = 35)

X-coord (GPS)	%	Y-coord (GPS)	%
2700000 – (West)	11	**6300000 – (South)**	3
2750000 -	43	**6350000 -**	91
2800000 + (East)	46	**6400000 + (North)**	6
Total	100		100
Average -coord	2786448	Average Y-coord	6374281

3.2.3 Spray Data

There was a full reporting of the most common spray regimes used by Hort16A growers in the database. The results here summarise the data by dividing the mineral oil applications into the number of times the vines were sprayed before and after full bloom, and the Bt spray data into the number of times sprayed after full bloom and the total number of times sprayed. This latter summary was done this way because only four orchards sprayed Bt before full bloom with an average of 12.8 days before.

Most orchards (54 percent) applied mineral oil twice before full bloom and once afterwards (49 percent) (Table 3.10), whereas most orchards (63 percent) used Bt spray three times after full bloom (Table 3.11).

Table 3.10: Percentage distributions of number of times mineral oil applied before and after full bloom (N = 35)

No. of times	% Before full bloom	% After full bloom
0	11	14
1	34	49
2	54	26
3	0	11
Total	99	100
Average times	1.4	1.3

Table 3.11: Percentage distributions of Bt Spray Applications (N = 35)

No. of times	% After full bloom	% Total applications
0	3	3
1	11	9
2	9	9
3	63	63
4	14	14
5	0	3
Total	100	101
Average times	2.7	2.9

3.3 Relationships between spray data and other variables of interest

Table 3.12a: Mineral Oil: Number of applications before full bloom and relationships with key production variables

No. of applications	No. in group	Average % larger fruit	Average % Grade 2 fruit	Average % fruit KiwiStart	Average % fruit Taste Zespri	Average fruit size
0	4	29	15 [a]	25	48	35.6
1	12	29 [b]	7 [b]	32	45	35.9 [a]
2	19	39 [a]	8	57	61	34.8 [b]
Total/Average	35	34.2	8	44.4	54	35.3

Table 3.12b: Mineral Oil cont.: Number of applications before full bloom

No. of applications	No. in Group	Average trays/ha	Average trays/ha larger fruit	Average trays/ha grade 2 fruit	Average trays/ha KiwiStart	Average Trays/ha Taste Zespri
0	4	3139	738	394	2157	617
1	12	5109 [a]	1469	353	1697	2302
2	18	3163 [b]	1217	272	1775	2048
Total/Average	34	3847	1250	315	1792	1970

Two applications of mineral oil before full bloom appears to be increasing the percentage of larger fruit, and the average fruit size but decreasing the average number of trays produced per hectare (Table 3.12a and b) when compared with one application. (This could be because Hort16A is more sensitive to mineral oil than Hayward Green before full bloom.) The comparison with no applications is probably not showing up because there are only four orchards in this category. Also, as Hort16A orchards are likely to be just coming into full production, orchard production data is likely to be more variable.

Table 3.12c: Mineral Oil cont.: Number of applications before full bloom

No. of applications	No. in group	Altitude (m)	GPS X-coordinate	GPS Y-coordinate
0	4	81	2758257	6364800
1	12	91	2781965	6375705
2	19	72	2795214	6375379
Total/Average	35	79.4	2786448	6374281

In Table 3.12c the variances of each group are not homogeneous for the GPS Y-coordinate so the data has not been tested for significant differences for this variable. It looks as if one or two spray applications of mineral oil before full bloom are more likely further East, than no applications, though this has not shown up as significant.

Table 3.13a: Mineral Oil: Number of applications after full bloom and relationships with key production variables

No. of applications	No. in group	Average % larger fruit	Average % Grade 2 fruit	Average % Fruit KiwiStart	Average % Fruit Taste Zespri	Average fruit size
0	5	33	5 [b]	22 [b]	41	35.4
1	17	33	13 [a]	41	46	35.3
2	9	36	5 [b]	69 [a]	43	35.2
3	4	35	3 [b]	31	44	35.5
Total/Average	35	34.2	8.4	44.4	44	35.3

Table 3.13a indicates that two sprays of mineral oil appears to be producing a greater percentage of KiwiStart fruit compared with no applications. This may simply mean that orchardists who are spraying are more likely to be offering their fruit for early picking. Table 3.13b shows that three applications of mineral oil after full bloom produced more trays per hectare of fruit and larger fruit, than no applications, at a 5 percent level of statistical significance. (The 3 versus 2 applications comparison is nearly significant.)

In Table 3.13c the variances of each group are not homogeneous for the GPS X and Y coordinates or the altitude, so no testing has been done for significant differences for these variables. However, it does look as if mineral oil is more likely to be applied three times after full bloom the further west the orchard, and twice the further east. Altitude does not appear to influence the use of mineral oil before or after full bloom.

Table 3.13b: Mineral Oil cont.: Number of applications after full bloom

No. of applications	No. in group	Average trays/ha	Average trays/ha larger fruit	Average trays/ha grade 2 fruit	Average trays/ha KiwiStart	Average Trays/ha Taste Zespri
0	5	2458 [b]	769 [b]	211	210	2140
1	16	3937	1234	465 [a]	1936	1715
2	9	3505	1294	154 [b]	2324	2423
3	4	5994 [a]	1811 [a]	210	2004	1759
Total/Average	34	3847	1250	315	1793	1970

Table 3.13c: Mineral Oil cont.: Number of applications after full bloom

No. of applications	No. in group	Altitude (m)	X-coordinate	Y-coordinate
0	5	75	2792149	6375854 (North)
1	17	75	2784250	6375088
2	9	88	2801443 (East)	6371248 (South)
3	4	85	2754496 (West)	6375711
Total/Average	35	79.4	2786448	6374281

Table 3.14: Bt spray: Number of applications after full bloom

No. of applications	No. in group	Altitude (m)	X-coordinate	Y-coordinate
0	1	8	2809155 (East)	6374858
1	4	68	2780726 (West)	6369858
2	3	59	2794388	6377372 (North)
3	22	77	2784794	6375929
4	5	125	2788995	6368600 (South)
Total/Average	35	79.4	2786448	6374281

Table 3.14 shows the relationships between orchard location and the use of Bt spray. It does look as if four applications of Bt spray after full bloom are more likely to be applied on orchards at a higher altitude. No further analysis has been carried out for the number of applications of Bt spray and the relationships with production variables because it was not considered to have any biological significance.

3.4 The impact of orchard size on production

When the sizes of the Hort16A orchards were related to the production variables the two or three biggest orchards appeared to produce smaller fruit than many of the other orchards. The bigger orchards (above 10,000 trays in total, and above four hectare in size) were more efficient in their production (trays per hectare) than about fifty percent of orchards smaller than these ones.

The next chapter provides a summary of all the analyses and concludes this report.

Chapter 4
Conclusion

4.1 Introduction

This report set out to 'data mine' the Zespri Organic Kiwifruit database to produce summaries of the variables of interest contained therein. These summaries provide a record of the 2002-2003 year for this industry. It also explored the relationships between many of these variables at a bivariate level in order to see if there were any patterns which could help orchardists grow bigger fruit, and fruit that could obtain the KiwiStart compensation and Taste Zespri premiums.

This chapter goes on to present a summary of the results of this data exploration. The limitations of these results are detailed and the possibilities for future research are outlined.

4.2 Summary of Results

One quarter of the fruit produced on Hayward Green orchards were of size 39, with nearly 33 percent of fruit less than size 36. Most orchards either recorded a KiwiStart or a Taste Zespri premium for most of their fruit or none at all with very few in between. Receiving one premium did not relate to receiving the other. The average size was 35.8 fruit per tray.

When Hort16A is considered the results are rather different with nearly one third of all fruit being of size 36, but with a similar percentage of larger fruit (34 percent). The results for the KiwiStart and Taste Zespri premiums showed similar patterns. The average fruit size was 35.3.

The average Hayward Green orchard produced 13,796 trays of fruit compared with 8,300 for Hort16A. When translated into trays per hectare production the Hayward Green figure averaged 4,177 trays per hectare while the Hort16A averaged 3,847. Hayward Green orchards had an average size of 3.8 hectares whereas for Hort16A the average size was 1.9 hectares.

Hayward Green orchardists used mineral oil on average 0.9 times *before* full bloom, and 2.3 times *after* full bloom. On the other hand most did not use Bt spray *before* full bloom but averaged 2.7 applications *after* full bloom. For Hort16A these figures were for mineral oil, 1.4 times *before* full bloom and 1.3 times *after*, with an average of 2.7 applications of Bt *after* full bloom. As for Hayward Green most Hort16A orchardists did not use Bt *before* full bloom.

When the different spray regimes were considered for Hayward Green there were many interesting significant differences showing up when various production variables of interest were contrasted with the number of applications of spray that were used. These can be seen in Tables 2.14 through to 2.16 and Graphs 2.5 to 2.9. They indicate that applications of mineral oil *before* full bloom may affect the percentage and trays per hectare of larger fruit, the average fruit size, the percentage of Taste Zespri fruit, and the trays per hectare production. Because of statistical issues it was not established what differences may be occurring for the spraying of mineral oil *after* full bloom, but there looks to be some difference occurring between three times of application and four, with the fourth application meaning a decrease in fruit size and production level. It is also apparent that mineral oil application *after* full bloom (but not before) appears to decrease the percentage and quantity of Grade 2 fruit produced.

The analyses of the different spray regimes for the Hort16A data are shown in Tables 3.12 to 3.14. For mineral oil, two applications compared with one *before* full bloom appear to be producing a greater percentage of larger fruit, and increasing the average fruit size, however it seems to adversely affect production of trays per hectare. No applications of mineral oil *after* full bloom compared with two applications does appear to be increasing the percentage of KiwiStart fruit, and three applications compared with none is increasing the trays per hectare production and trays per hectare of larger fruit.

The limitations of geography for Hayward Green production were considered by examining the scattergrams of the relationships between some key production variables and the altitude and GPS location data for orchards. This demonstrated that probably altitude and the further west or south the orchard limits the production of larger fruit and the potential for KiwiStart fruit. However, altitude and location did not appear to limit the total production in trays per hectare or the attainment of the Taste Zespri premium.

For Hayward Green production there is no consistent evidence that the size of an orchard canopy or the total number of trays per orchard means more efficient production or the production of a greater percentage of larger fruit, or a larger average fruit size, or a greater percentage of fruit achieving KiwiStart or Taste Zespri premiums.

When the sizes of the Hort16A orchards were related to the production variables the two or three biggest orchards appeared to produce smaller fruit than many of the other orchards. The bigger orchards were of about average efficiency in their production (trays per hectare).

4.3 Limitations and Further Work

Throughout this report special care has been taken to make it clear that these results come from a database collected for other purposes and hence it has been a data 'mining' or data dredging exercise, the purpose of which was to produce possible areas that may be of interest to future research using more stringent statistically designed experiments. The methods of analysis have not been able to take account of any intervening variables and hence the results may be confounded by other variables. Further work could go beyond the bivariate analysis and attempt to incorporate covariates or multivariate dimensions to try to account for this but nothing would match especially designed scientific experiments.

The authors of this report are not experts on kiwifruit production and hope that this report leads to others exploring further the results presented here.

This report recommends that:

- The industry decides what variables should be systematically collected and analysed on an annual basis.
- What other variables would need to be collected to identify what makes the production on some orchards better than on others? (Pruning, manuring, pollination etc. The challenge would be to find ways to define and measure such variables accurately in ways that matched across all orchards.)
- There needs to be an accurate database of orchard size that can be related to individual orchards and grower numbers.

Throughout these chapters possible areas for further work on these data have been mentioned, such as producing more graphs for the Hort16A results. Apart from these possibilities there are other areas for suggested exploration also. The size variability could be studied by comparing the ranges or variances of each orchard to see if some were producing less variation in their fruit size. The relationship between the mean average size and its

variability for each orchard could also be of interest to see if a lower average size meant less variation. As mentioned earlier, there has been no analysis of the dry matter database which could also be explored for variability with a comparison of between orchards and within orchard variation.

If data were collected over at least two production years a comparison could be made to see which orchards are consistently reaching high levels of production of particular attributes such as larger fruit, or achieving certain premiums.

Another possible area of research is the relationship between the different types of orchard ownership and management and production levels.

4.4 Conclusion

This database has been a rich source of descriptive and interesting analyses of the production of organic kiwifruit in the New Zealand industry over the year 2002-2003 season. It makes many links about the enhancement of that production by a consideration of spraying regimes and geographical location, and there are many more ways in which it could be used to suggest future areas worthy of further exploration and research.