Defining the cost of within orchard production variability on the overall profitability of a NZ apple orchard.

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Contents

Executive Summary

Growing conditions in New Zealand have historically been recognised as being some of the best in the world for producing exceptional volumes of excellent quality apples. To remain financially sustainable New Zealand apple growers need to specifically focus on their natural strengths, ensuring that the production they achieve maximises the advantage of their location.

NZ apple growers have spent significant time and focus on cost reduction in orchards this may have been detrimental to overall profitability. The NZ apple industry does not have the same access to cheap finance as many of its international competitors such as the USA. New production techniques generally come with significant costs, areas of new production have a relatively long lag time from initial investment to final repayment. New growing systems also have financial risk, with the potential cost of mistakes made during the learning and development process.

Increases in the overall production of market acceptable apples can be achieved by ensuring all trees are working individually at an optimum level with minimal variation between them. This has potential for gains in cost reduction, resource use efficiency, minimisation of fruit quality variability and improvement in overall profitability.

To ensure tree to tree variability is minimised systems need to be created to efficiently measure key differences between trees. Similar populations of trees are grouped and then analysed to quantify each groups impact on overall block performance, in an easily understood format.

Beyond the skope of this project, tree to tree variability information can be used to assist with investigations into potential solutions and financially justifying the cost of variation mitigation.

This study was undertaken in a commercial Royal Gala apple orchard with 6159 - 10 year old trees planted on M9 rootstock. The assessment focuses on 1887 trees within this block. The use of trunk diameter measuring was decided as the basis for ranking variability. Fruit size and total fruit number per tree was assessed in a small trial. 5 different trunk size groups were eventually formed and the profitability of these assessed using a computer based profitability benchmarking model.

- The missing new trees returned a negative profit of -$19,755 per ha.
- Weak / small trees returned a profit of $ 8,516 per ha.
- The average size trees returned a profit of $14,435 per ha (approximately the same as the overall block profitability)
- The largest of the average trees returned a profit of $21,344 per ha
- The excessively large / scion rooted trees returned a profit of $5,435 per ha.

Introduction

Apple growing around the world is a relatively difficult industry to be financially successful in. It involves a high fixed cost structure, a long time lag from significant initial investment to final financial reward and incurs consistent potential risk due to the weather and market volatility. Current NZ arrangements see growers getting paid at the end of the value chain, because of this they tend to wear the cost of all mistakes made. When growers are able to achieve maximum volumes of the correct fruit, in the correct markets, at the correct time, apple growing can be financially rewarding. The apple industry also creates large employment opportunities with a significant amount of the initial market return going beyond the orchard gate to the community beyond.

One of the logical points of focus for trying to improve financial viability in business is cost reduction. New Zealand apple growers have specifically looked to this area for many years, this has not always been successful. In many situations cutting costs has had a negative impact on overall production or fruit quality and has lead to even more financial hardship. Increased production of market acceptable fruit decreases overall production costs.

In more recent times older planting systems or varieties were deemed to be financially unsustainable, many individual orchard businesses carried out extensive redevelopment programmes. Significant investment was made towards large areas of new apple varieties on new intensive growing systems. The cost of investment required for redevelopment and the time lag to achieve optimised production and profitability, increased the cost of production in the short term. During this period market returns did not meet expectations, and a number of growers were forced to exit the industry.

Both the singular management focus on production cost reduction, and the significant investment outlay required for total system change are significant financial risks to the New Zealand Pipfruit industry and need careful consideration and management.

Production businesses have a simple profitability matrix of market returns x production - less costs.

Market returns are a product of the supply and demand tensions of the markets but they require the underlying acceptance that - To achieve the available market returns requires within market quality specifications to be met.

While multiple levels of markets quality acceptance is available, the quality specification of individual markets is effectively a fixed factor – you either meet or exceed expectations in a specific market or you do not. Selling for a lower price at a lower quality specification market might not be financially viable.

Different markets can have different quality parameters, trying to “sell” a quality parameter such as high colour apples in a market where this parameter is not value perceived does not increase the value of the product. Growing fruit to a specific size for the market expectations is also a quality parameter. Fruit size

is one of the most important determinations of price (Berg, 1985). Therefore maximizing the production of preferred size apples is a key parameter in achieving the ultimate in market returns.

Producing apples with minimal variability that consistently achieve market quality requirements is an important factor in ensuring optimum market returns.

Market quality specifications are fixed parameters that must be met. Individual markets will have different quality requirements but they will include (but not be limited to) factors such as fruit size, fruit sugar levels, and flesh firmness. Management decision changes that are made in the apple production chain should not be to the detriment of the market quality specifications. Reduction in the cost of apple production is only beneficial if it has no negative bearing on fruit quality.

Improving the production of market suitable yield on existing orchard operations has significant other potential benefits such as - Improving the financial competitiveness and acceptance of NZ apple growers in the world market, reducing fruit quality variation and the supply of sub standard fruit to markets (improving overall fruit quality and decreasing the cost of in market fruit loss). Maximising yield also improves the environmental footprint of the crop, by improving the use efficiency of significant resources per kg of fruit produced, these resources include total land area required, water use for irrigation, fuel, pesticide, nutrient …..

(Wilton J 2009) "Growing Fruit for Profit – Avoid Mistakes in the Orchard."

Significant scientific research has been carried out around the world with the aim of improving the production capabilities of apples. Literature reviews indicate much of the scientific focus is on finding all encompassing orchard management improvements and solutions aimed specifically at the entire orchard business system or at the orchard block level. The potential gains that might be achieved from complete orchard system change should always be weighed against the costs, both real and potential that might be incurred during the implementation of changes (including the cost of potential mistakes).

The Orchardnet® Data base produced by AgFirst contains a significant amount of actual block production and profitability figures for individual apple blocks over many different years of production. The "Block Analysis Report" in OrchardNet® uses industry average returns by count size and industry average costs (including overheads) to produce a pre-tax profit figure. Different blocks of the same variety of apples show extreme profitability variability in the same year. For example -The variety Royal Gala in 2011 (regarded as being a poor return year) have a profitability per orchard hectare range from $33,681/ ha (the best block in the data base), $10,233 /ha as the 25th percentile (top) result and $1,447 /ha as the average in the data base. Significant losses were made by those growers that achieved production results that were less that the average. Growers have used this data base to try to understand and improve the performance and profitability of their own individual blocks and inevitably their entire orchard businesses. Block production results have been measured on orchards for many years but significant profitability improvements have been made recently since the results have been reported in a format that growers instantly understand – Profit per ha.

(Wilton J 2010) Tree to tree "variability kills performance"

It is widely accepted where you are able to visually recognise an output change between difference trees in an orchard situation this does not occur until there is at least a 20% difference in output results. A typical commercial orchard system has visual tree to tree variability in the canopy size of trees within it. Minimization of this variability should improve overall profitability. The variability needs to be first identified, then the potential for improvement financially quantified (to allow for commercial “tension to change” decisions to be made), and then management plans created to ensure that best practice techniques are carried out across the different types of trees that exist within a block.

In other production sectors concepts of business improvement systems and ideas such as continuous improvement and lean manufacturing have been focusing on these types of internal business gains for many years. In the agricultural sector we have already started down this idea path, with precision agriculture strongly focused on identifying, quantifying, reducing and managing variability in other farming systems.

Scientific trials carried out in commercial apple properties are generally designed to work around, and not specifically focus on, the natural tree to tree variation that exists in commercial orchards. To “prove” or “disprove” different factors that are being measured in the process of scientific validation, natural within block variability is “managed” with replicated trial design to a point where the statistical significance can be identified.

Photo showing - Consistent bloom and canopy in an Envy™ apple block producing 100 Tonnes per/ha significantly above industry average production levels.

Objective

The objective of this research is to measure and quantify the financial impact of tree to tree variability within a specific commercial apple block.

A simple but effective orchard variability performance indicator needs to be researched and identified to measure tree to tree variability. The results can be grouped into types of trees of similar type.

The potential financial profitability of each specific group of trees will be assessed and presented as a potential profit per ha result. Allowing easy assessment for growers as to where financial gains can be potentially made and how much the gains are likely to be.

This piece of research is not aimed at finding the solutions to the variability that might exist in an apple orchard. In the future it is envisaged that within block profitability modeling will produce output information that can then be used to assist in the creation of specific best practice management plans for different groups of trees that might exist in a block. Identifying, quantify and managing within block variability will increase the overall productive capacity of market quality fruit that each block is achieving, and potentially decreasing overall production costs.

Figure 1 – Smaller trees

Figure 2 – Medium Trees

Figure 3 – Larger / Scion rooted trees

Variability of tree size in a commercial Royal Gala orchard in Hawkes Bay

Methodology

Block Selection

The trial site selected is a commercial apple orchard planted in the variety Royal Gala on M9 rootstock. The trees were planted in 2003 with a spacing of 3.5 m x 1.5m. The block canopy development would generally be assessed as "full production" with tree to tree size variability across the block at a level that would be considered "normal" for a commercial orchard.

Using the AgFirst benchmarking software Orchardnet® the production and profitability of this block has been about average for Royal Gala production in New Zealand, with above average results for the year of assessment 2013.

Measuring variability within orchards.

Literature Review –

Productivity of intensive apple systems has been shown to be directly proportional to orchard light interception in a number of studies around the world (Lakso 1994; Palmer et al. 2002).

(Palmer et al. 2006) - Found that total harvested yield is linearly related to light interception (r^2=0.83) Actual light interception between blocks can range from 23 – 63%. Fruit quality is highly correlated with light distribution within canopies (quality decreases as shade decreases) In areas of apple canopy where very high light interception took place, measurements of 17-18% irradiance on the ground suggested that fruit at the base of the canopy are growing in too shaded a position. Light interception could be estimated from Tree Row Volume (TRV) (r^2=0.81 recorded in the spring) and Trunk cross-sectional area (TCA) (r^2= 0.90 in autumn). TCA is a measure of accumulated growth over the life of the tree and only ceases to increase when the tree dies. TRV is a better measure of tree canopy volume (once full canopy development is reached) but with no indication of the canopy density.

(Robinson T 2008) Found that there was a significant negative relationship across all rootstocks between crop load and tree growth as measured by increase in trunk cross sectional area.

J Brookes 2009 (unpublished data) investigating the effect of winter fruit bud numbers and crop load on tree growth indicated that lowering winter fruit bud number per TCA had a correlation with increasing accumulated annual shoot growth and increasing % TCA size increase.

McKay et al 2010 indicated that fruit Dry Matter Concentration (DMC) was a good indicator of eating quality of apples at expected out-turn. Higher DMC fruit had potential storage advantages, better fruit colour development. A calm tree with good light penetration was needed to produce high DMC fruit.

In assistance with the information above I have concluded that total yield is related to light interception. TRV and TCA are related to light interception. Excess light interception (too much shading) decreases fruit quality. TCA is a measure of accumulated growth over the life of a tree, many factors can create this difference in TCA accumulation over time such as wind, drainage, irrigation, crop load management….

Measuring the TRV of individual trees requires access to expensive specific scientific equipment -such as Lidar (Polo JRR 2008) TRV measurements are possible to do by hand but the time requirements to do individual tree TRV assessments in a commercial orchard makes this option not commercially viable. In a well pruned orchard situation TRV measurements may not accurately indicate the presence of Scion rooting (a factor that mitigates the positive effects of dwarfing apple rootstocks caused by poor planting depth management). "Scion rooting is a serious problem, even in good orchards" (Barritt B Good Fruit Grower 2009), "estimates 5% of all apple trees on Washington State have a problem with scion rooting"(Allan D - Good Fruit Grower 2009).

Overall findings indicated that measuring individual tree TCA was a good option for indication tree to tree variability in a commercial orchard, with a good combination of accuracy, cost effectiveness and simplicity. Other assessment methods such as TRV might have different strengths and a combined measurement system could be the best ultimate solution to tree to tree variability measuring.

Measuring Trunk Diameter

Individual trunk diameters were measured on 1887 trees in a contiguous block on 03/01/2013 (representing 30.6% of the total orchard area). A Willowbank digital Bluetooth caliper was used and the data was entered into a smart phone. The information was then down loaded into an Excel spreadsheet and converted to cm^2 TCA for assessment.

Both TCA and trunk diameter are referred to in this report. References to specific crop loads are made in fruit number per cm^2 TCA and references to different size trees are in trunk diameter.

Variation in trunk diameter in an established orchard population can be caused by a number of factors, identifying the cause of these factors is not the function of this research. The trunk diameter does indicate the potential maximum yield and can indicate quality potential of each tree.

The presence of small and very small trunks in an orchard population of trees indicates increased plant stress over the life of these trees. This stress decreases the excess photosynthate production that is generally channeled into normal trunk growth, excess crop load during the life of a tree can be a significant factor in decreased trunk size. Converse to this excessively large trunks indicate significant partitioning of photosynthate produced in trunk expansion. A small number of the very large trunks were visually assessed to try to understand the reason for the excess growth, it was concluded that the excessive increase in TCA over the life of the biggest trees was either due to under cropping during the life of the tree, or in most occasions the trees were planted too deep at planting time and the dwarfing rootstock had been over taken with the Royal Gala scion roots.

Measuring fruit numbers and average fruit size per tree

Initial TCA data analysis indicated an average TCA for the block of $31cm^2$ (61.6mm avg diameter)

The 25th percentile TCA was calculated as being $23cm^2$ (54.1mm avg diameter)

and 75th percentile TCA was calculated as being of $37cm^2$ (68.8mm avg diameter).

Further assessments to look at average fruit size and fruit numbers per tree were decided around these figures, they were classed as small trees, medium trees and larger trees.

The 3 different sub groups of trees were assessed to identify if different crop loads and total fruit number existed on each style of tree. For statistical analysis 4 replicates of each tree style were measured.

All fruit on selected trees were measured 15/02/2013 (about 1- 2 week pre harvest) using digital calipers and measurements converted to estimated fruit weights. To minimise variation impact from other factors such as irrigation, all assessments were carried out in one row (row 10) with a randomised design based on appropriate trunk size required.

Statistical analysis was carried out on total fruit number per treatment and average fruit size per treatment.

Grouping of trunk diameters into similar sizes

Initial TCA grouping was around average TCA, and Upper quartile average, and lower quartile averages.

Due to the actual spread that naturally existed in the block this spread of 3 groups was later deemed not wide enough and 5 groups were eventually decided upon (New trees, small average, medium average, large average trees and oversize trees). Each group was assessed and demonstrated as a % of the total orchard population.

TCA results were also mapped in Excel using different colours to allow for visual assessment of results, this mapping could be used in the future to look for potential causes and solutions to the variability.

Profitability Assessments

The benchmarking Analysis Report in OrchardNet® software was used to assess the profitability potential of each of the similar group of trees, the actual orchard results and average of all the collected data were also recorded. The financial results of each group are driven by fruit numbers, average fruit size, and packed recovery. All costs in this report are assumed industry average to allow for orchard production, fruit size and class 1 recovery benchmarking comparisons.

Due to the fruit size assessment results of the treatments not showing statistically significant differences the actual fruit size results of the block were used in the financial modeling of the different groups.

The actual fruit packout % results were used in all situations apart from the extra large trees.

Initial fruit numbers were not made on the very large tree as they were not initially included in the assessment, all literature information, and professional experience would indicate the same or lower crop load per tree than average, a lower harvest recovery % than average and a lower export recovery from these trees. Further information may be required to support this but it was assumed that these trees achieved the same fruit number per tree as the average with 5% less recovery off the tree and 13% lower pack out than the other trees due to poor fruit colour.

Results

Trunk Diameter measurement results

A total of 1887 trunk diameters were measured representing 30% of the total trees in the block. The diameter was converted to TCA and depending on use can be referred to as trunk diameter or TCA. The data analysed indicated an average TCA for the block of 31cm² (61.6mm avg. diameter) 0.25 percentile TCA of 23cm² (54.1mm avg diameter) and a 0.75 percentile TCA of 37cm² (68.8mm avg. diameter).

From these numbers a small trial area was set out to look at average fruit size and total fruit per tree.

These results were mapped into Excel to show average trunk size and trunk TCA this information can be used for understanding the reasons behind the tree to tree variability once the profitability analysis is carried out to assess if management input is justifiable.

Below is a segment of the overall trunk results assessed - converted to TCA and colour coded.

Trunk Cross Sectional Area (cm²)- Grand view - House to Oaks 03/01/2013

Tree #	Row 1	Row 2	Row 3	Row 4	Row 5	Row 6	Row 7	Row 8	Row 9	Row 10	Row 11	Row 12	Row 13	Row 14
1	40	35	52	26	56	47	41	40	45	21	41	50	52	44
2	23	29	41	49	20	46	39	26	17	30	41	33	34	25
3	27	35	29	21	32	32	26	36	30	43	38	30	29	42
4	18	22	31	21	22	27	30	19	57	24	52	42	34	41
5	33	29	29	30	31	28	38	24	25	25	51	27	29	47
6	28	32	52	30	25	57	25	39	44	20	52	26	33	32
7	27	27	28	26	26	29	46	24	29	27	35	19	46	40
8	19	32	24	26	22	39	24	32	55	22	57	36	41	40
9	29	27	26	27	21	27	35	42	21	26	61	30	38	33
10	22	22	35	35	38	47	51	29	28	33	47	30	62	48
11	16	24	33	29	0	24	46	46	27	22	36	39	46	40
12	16	31	36	21	34	27	29	36	29	28	42	29	26	75
13	15	32	21	34	50	29	29	42	43	46	23	39	48	49
14	31	28	34	27	46	28	24	24	20	25	50	39	43	51
15	17	14	20	26	29	25	26	18	54	22	20	42	40	42
16	20	31	35	19	21	29	37	44	59	37	42	26	76	41
17	26	28	29	21	42	36	38	31	45	41	46	39	34	49
18	22	23	38	29	30	29	29	31	61	30	54	38	62	47
19	23	25	26	33	43	27	21	75	80	43	37	33	38	28
20	21	25	16	21	22	33	41	40	30	34	36	50	28	45
21	29	24	27	21	57	93	47	42	30	39	132	32	44	40
22	20	26	24	20	32	21	34	47	48	33	49	47	30	0
23	16	0	32	34	42	36	31	49	36	33	51	33	41	0
24	18	0	30	35	36	22	34	42	42	38	45	53	27	34
25	16	24	23	28	38	45	35	31	27	44	45	39	45	28
26	16	29	28	32	37	19	44	26	43	20	32	26	27	57
27	15	31	30	24	43	41	36	30	34	19	34	87	34	30
28	22	22	121	22	18	40	36	53	45	27	49	28	28	25
29	17	31	30	22	36	99	38	28	37	26	28	36	32	32
30	24	25	27	29	22	21	36	38	29	25	160	30	27	24
31	16	33	28	22	29	44	27	27	36	33	25	34	68	41
32	19	15	27	26	34	28	49	31	26	33	33	45	41	27
33	21	29	24	21	45	21	34	45	46	36	45	21	34	38
34	20	18	27	33	25	26	38	29	27	25	27	51	0	52
35	24	39	32	35	30	35	23	26	39	28	47	43	51	80
36	25	0	31	26	51	43	40	27	26	19	39	17	43	20
37	20	30	50	47	29	40	32	47	37	23	70	30	41	106
38	18	19	29	20	37	33	41	71	37	28	34	35	31	47
39	27	24	26	23	42	42	28	30	29	0	44	26	40	32
40	17	33	20	28	24	25	37	26	36	43	29	43	46	31

Fruit size and total fruit per tree results.

As specific earlier the fruit assessments were the average fruit size and crop load per tree on the lower quartile average tree size, the average tree size and the upper quartile average tree size. They were classed as small trees, medium trees and larger trees. The 3 different sub groups of trees were assessed to identify if different crop loads and total fruit number existed on each style of tree. 4 replicates of each tree style were measured; this may have had an impact in the definition of statistical difference.

To minimise variation impact from other factors such as irrigation, all assessments were carried out in one row (row 10) with a design based on appropriate trunk size required. All fruit on selected trees were measured 15/02/2013 (about 1- 2 week pre harvest) using digital calipers and measurements converted to estimated fruit weights.

Row 10	Tree #	Trunk Dia (mm)	TCA cm²	Fruit # / tree		Fruit # / TCA	Calc avg fruit weight (g)	
	2	61	29.6	276		9.3	154	Orange
	3	74	42.9	350		8.2	159	Red
	4	55	23.6	232		9.9	151	Yellow
	7	59	27.0	295		10.9	149	Orange
	8	53	22.3	311		13.9	151	Yellow
	10	65	33.2	285		8.6	145	Orange
	11	52	21.6	165		7.6	155	Yellow
	13	76	45.9	339		7.4	158	Red
	15	53	22.1	290		13.1	153	Yellow
	17	72	41.2	415		10.1	143	Red
	18	62	29.9	357		11.9	139	Orange
	19	74	42.9	342		8.0	136	Red
		Trunk Dia (mm)	TCA cm²	Fruit # / tree		Fruit / cm²		
Average	Yellow	53.4	22.4	250	*a	11.1	152.5	a
	Orange	61.7	29.9	303	*ab	10.2	146.8	a
	Red	74.2	43.2	362	*b	8.4	149.0	a
Average all		63.1	31.2	305		9.9	149.4	

LSD (P=0.05)

*ab Statistical analysis of the total fruit numbers per tree indicated no statistical difference between the small and middle tree, as well as the middle and large trees but a statistical difference between the small and the larger trees. a Statistical analysis indicated no difference in the average fruit size of the 3 styles of tree measured. Due to this information it was assumed that fruit size was not significantly different across the tree types measured but fruit numbers per tree between different groups of trees could vary significantly.

Orchard management grouping based on Trunk Size.

After fruit size and fruit counts were assessed the total range of TCA was re-assessed and 5 groupings were decided upon that gave a better representation of the different styles of trees that existed within this block.

The final definitions of tree variation types were regarded as

0 – 15mm diameter – Missing or new trees – approx 2% of the total

30 – 54mm diameter - Weak or small average trees – approx 25% (yellow - small average tree assessed)

55 – 69mm diameter – Average size trees – approx 45% (orange - average tree assessed)

70 – 79mm diameter – Average Large trees – approx 20% (red – large average tree assessed)

80mm+ diameter – Extra large trees - scion rooted etc approx 8%

Different trees sizes that exist in the block

Fig 1 Blank / new tree

Fig 2 Small Tree

Fig 3 Larger average tree

Fig 4 V large / scion rooted tree

Financial impact results.

The financial impact modeling was carried out using Block Analysis Report on Orchardnet® Software (AgFirst HB Ltd). The "Block Analysis Report" in OrchardNet® uses industry average returns by count size and industry average costs (including overheads) to produce a pre-tax profit figure. The impact of the different tree variation groups is presented in a dollars profit per ha format. It is my belief that this presentation method is the format most easily understood by growers and allows them the ability to easily assess whether tree to tree variability improvement is justified and subsequent solutions and management changes are required. OrchardNet® software is used extensively for commercial orchard data storage and analysis both in New Zealand and internationally.

Once TCA variation was assessed, then fruit number and size at different TCA measured the data then needed to be converted through a process where the cost of this tree to tree variation could be defined.

The block analysis financial report is a block vs block benchmarking report that uses industry average costs per year and the 3 key financial matrix parameters for apple production (production per ha, export recovery % and average fruit size) to produces a profit per ha result.

The actual block results for the entire property returned a profit of $13,153 this included all of the natural variability that existed in the property.

Fruit size and pack out % were assumed to be consistent across the block. It is highly likely that the fruit size in the smallest of the weak trees would be smaller that our measured trees. One of the key reasons for apples trees remaining small is due to excess crop load per TCA we did not measure this and have assumed the fruit size was constant. It is also likely that the export quality fruit recovery % in the larger trees (above 80mm diameter) would be lower than the average due to excess vigour (leaf cover) creating increased shading - this has been factored into the profitability matrix.

During the financial impact assessment 7 different crop load, vs fruit size, vs quality fruit recovery (packout %) scenarios were assessed. I have listed them in order of descending profitability.

The highest profit return was the Red Large trees I have grouped all trees from 70 – 79mm in this group. The trees assessed ranged from 72 – 76mm these were the biggest trees in the average group (not excessive)This represents about 20% of the total population and had profitability of $21,343 per ha

The second profitability assessment was a combined result for all of the assessment trees to see if the yield and size sample area was representative of the overall orchard population. The profitability was one of 3 closely grouped around the average results. This area had a profit of $14,590 per ha.

The third assessment was from the orange trees (average tree size) assessed in the yield / size assessment. (ranging from 59 – 65mm in diameter) The overall average group is from 55 – 69mm dia. and is approximately 45% of the total orchard population. The profit from this was $14,435 per ha.

The forth group was the actual block results that were achieved by the grower. These were close to both the orange assessment and the average of all trees assessed with a profit level of $13,153 per ha.

The fifth group was the yellow small trees from the yield / size assessment. This group is from 30 – 54mm dia. and represents about 25% of the orchard population. The trees assessed were from 52 – 55mm this is at the higher end of trunk diameter for this group of trees and the actual result is likely to be lower than the $8,516 profit predicted by the software.

The 6th Group of trees is a combined group of all oversize trees. As stated earlier initial yield and size assessments were not made on the very large trees due to the small % in overall population. Literature information, and professional experience would indicate a per tree crop load that was the same or lower than the average, a lower harvest recovery % than average and a lower export recovery. It was assumed that these trees achieved the same fruit number per tree as the average with 5% less recovery off the tree and 13% lower pack out at the pack house due to poor fruit colour development, further assessment may be required to support this. With trunk diameters above 80mm this group represents approximately 8% of the orchard population and has $5,435 profit per ha.

The last group assessed through OrchardNet was also not included in the initial yield size assessment. This is the trees that are either missing or very young with an average trunk diameter of 0 – 29mm this only represent approximately 2% of the orchard population but is making a loss of $-19,753 profit per ha. This is assuming an average crop load of these trees of 10 apples per tree and the neighbouring trees not filling up the allotted space that was designated for these trees.

Tree Diameter	Total Trees	%	Fruit Size & Tree counts	Trunk diameter groups for orchard management decisions	Group %	profit/ha from OrchardNet®
0 - 15mm	32	1.7%		Missing / new trees	2.0%	-$ 19,755
30-39mm	9	0.5%				
40-49mm	190	10.1%				
50-54mm	269	14.3%	Yellow	Weak / small trees	25.0%	$ 8,516
55-59mm	305	16.2%				
60-64mm	363	19.2%	Orange			$ 14,435
65-69mm	275	14.6%			45.0%	
70-74mm	198	10.5%	Red			$ 21,344
75-79mm	118	6.3%		Average trees	20.0%	
80-84mm	61	3.2%		Large trees / scion		
85-89mm	23	1.2%		rooted etc.	5.0%	$ 5,435
90-99mm	17	0.9%				
100-109mm	11	0.6%				
110-119mm	9	0.5%		Excessive large trees /		
120-145mm	7	0.4%		scion rooted etc.	3.0%	
	1887	100.0%			100.0%	
The average of the fruit size / count data collected					91.0%	$ 14,590
Actual grower block information for 2013 season						$ 13,153

2013
Royal Gala
New Zealand
183 Blocks Assessed

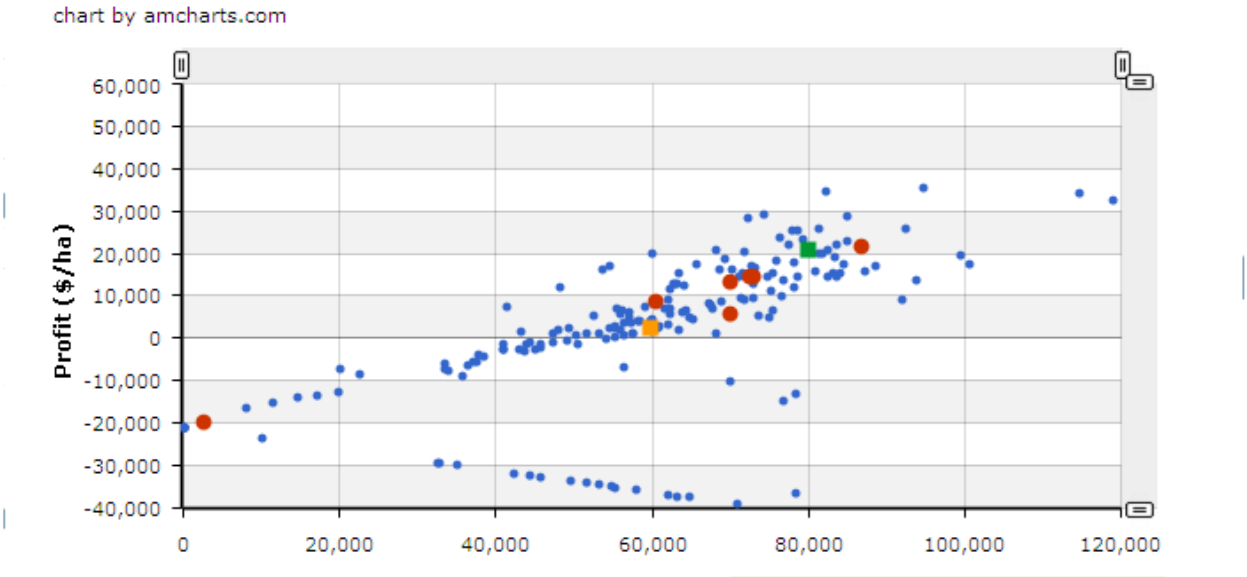
Block Analysis Report

AgFirst Hawke's Bay - JB Kelloggs info - PS1 - Actual Block Average

ranked by: Gross Yield (kg/ha)

Comparison: Type - Royal Gala

Actual industry costs and returns are not currently available for this year, so estimate values have been used



The red dots on the graph above indicates the profitability ranking of 7 different scenarios of trees using OrchardNet® software (2 of the dots are basically over top of each other at $14,000 profit per ha).

Data on graph is made up of 183 individual blocks worth of Royal Gala information in the 2013 harvest season. All blue dots indicate entered information for other unidentified growers with the yellow square representing the average profitability of the population and the green square representing the upper quartile average. At the time of writing this 16 of these properties have entered gross yield data but not fruit size or pack out % data, these are showing up as the blue dots with $-30,000 profit levels.

The graph represents the huge variability that exists between individual blocks of trees and with the data entered through this project the large amount of variability that can exist within a block of trees.

The information presented above indicates that a relatively large opportunity for improvement is potentially possible both between blocks and within blocks. The next step is to understand why this variability exists and create appropriate management plans to try to improve overall block profitability through the minimization of tree to tree variability.

Rank	Block Name	Gross Kg per ha	Class 1 Kg per ha	Packout	Fruit Wt (g)	Income	Profit
	Upper Quartile	**79,951**	**70,123**	**88%**	**171**	**$88,670**	**$20,919**
	Average All	**59,607**	**46,244**	**76%**	**157**	**$56,626**	**$2,865**
1		94,858	84,036	89%	185	$112,015	$35,192
2		82,381	72,865	88%	204	$103,734	$34,286
3		114,736	96,378	84%	157	$120,913	$34,075
4		119,116	111,132	93%	133	$123,622	$32,275
5		74,435	65,279	88%	205	$93,642	$29,040
6		85,161	70,174	82%	187	$97,973	$28,527
7		72,340	60,911	84%	214	$90,828	$28,256
8		92,562	71,405	77%	191	$97,765	$25,659
9		81,481	72,534	89%	180	$94,642	$25,575
10		78,621	76,925	98%	165	$94,688	$25,103
11		77,922	70,222	90%	178	$92,318	$25,077
12		76,444	71,093	93%	172	$90,776	$23,711
13		79,394	73,836	93%	168	$92,230	$23,389
14		85,045	71,863	85%	176	$92,730	$22,784
15		77,551	68,245	88%	178	$88,535	$22,036
16		83,667	72,790	87%	169	$91,580	$21,762
17	Red Avg Large trees	86,805	76,388	88%	162	$93,267	$21,343
18		82,525	70,394	85%	171	$89,457	$20,750
19		68,341	63,557	93%	180	$82,776	$20,590
20		71,824	64,070	89%	180	$83,591	$20,174
21		60,000	50,520	84%	214	$75,334	$19,847
22		81,979	74,800	91%	153	$89,697	$19,758
23		81,461	71,686	88%	160	$88,467	$19,676
24		99,649	85,867	86%	137	$97,081	$19,411
48	Average of all data collected	72,973	64,216	88%	162	$78,406	$14,590
52	Orange Avg Middle trees	72,656	63,937	88%	162	$78,065	$14,435
56	Actual Block Average	70,030	61,626	88%	162	$75,244	$13,153
74	Yellow Small Trees	60,533	53,269	88%	162	$65,039	$8,516
90	Scion Rooted	70,000	52,500	75%	162	$64,618	$5,435
160	Nursery trees	2,632	2,316	88%	162	$2,827	$-19,755

The table above shows the same information as the previous page but in a format that allows a breakdown of the yield, fruit size and pack out % to be seen. This can be then used to understand where ultimate profitability is being generated by others.

I think it is important to note that the average of this population is making $2,000 profit per ha (this is being influenced by 16 blocks of unfinished data, the upper quartile is making $20,000 profit per ha and 3 blocks are recording about $35,000 profit per ha.

Discussion of Results

After measuring 1887 trunks in a commercial apple orchard it was shown that a lot of variability existed in the diameter of each of the trees.

This variation is an indication or accumulation of effects that have taken place over the approximate 10 year life of the tree. Solutions to why variation the exists are probably achievable with the visual trunk size colour mapping showing up potential wind effect on one side of the block and poor planting technique (increased scion rooting) in one row as one of the planters who are meant to check that plants are not planted to deep possibly got a bit tired. It is quite likely that other factors such as irrigation application, soil drainage, frost, tree support structure failure, and year to year crop load could all have impact on the ultimate trunk size that each tree has achieved.

The fruit size in this assessment was assumed to be the same across all treatments, if crop load was historically excessive on some trees this would have the effect of reducing the increase in size of the specific tree trunks from year to year. It is also quite likely that the fruit size on these trees could be smaller and this could have a further reduction in the overall profitability of these trees.

Knowing the problem exists and finding what to do about it are only part of the solution. By using the OrchardNet® software I was able to profitability test different scenarios using fruit number per tree, average fruit size and the quality fruit recovery (packout %). This allowed me to quantify the financial impact of different groups of trees.

Looking at these results and assuming 2013 financial returns I believe it is a realistic goal for this block to aim for a 50% increase in profitability from $13,000 per ha to $20,000 per ha. This could be achieved through adjusting the existing tree canopy size to the equivalent of the trees grouped as “Red average large trees” Solutions to reaching this for each of the existing groups will need to be done on a group by group basis.

Once the canopy is able to be developed to achieve this tree size consistently it is likely to mean overall gross income will increase from $75,000 per ha to $93,000 per ha, the packed yield will increase from 61 Tonnes per ha to 76 Tonnes per ha and the $7,000 profit per ha increase will mean an increase of $23,000 directly to the grower per annum off a small block of Royal Gala. This financial assessment gives the grower the ability to decide if putting in effort to chase this extra potential profitability is justified.

As trunk size increases the optimum fruit number per TCA declines until full canopy development is reached. In situations where tree size variability did not exist and the canopy was fully developed using the fruit number per BCA (Branch Cross-sectional Area) is appropriate yield optimisation tool.

Conclusion

An average block of apple trees growing in New Zealand that was initially assumed to be relatively consistent has a lot of variation in the size of the individual trees within it.

The financial impact that this tree to tree variability is having on the overall profitability of the block could be a serious factor in the financial sustainability of the orchard business.

The solutions to addressing tree to tree variation will only be found when the variation is able to be easily quantified in a format that encourages growers to assess if solutions to the variability are financially viable.

One of the major issues identified in the variability was Scion rooting, this is where the trees are planted too deep and the graft union is effectively underground. The dwarfing rootstock effect gets bypassed and the much more vigorous scion produces roots and makes the tree grow excessively.

All planting systems (old and new) run a significant risk of incurring a level of variability within the block unless significant focus is made to minimise variability from well before planting takes place and throughout the life of the trees.

General Comment

In 2013 Pipfruit NZ stated an industry goal of $1 Billion by 2022. To achieve this the New Zealand Pipfruit industry needs to potentially increase production by approximately 1/3 from current levels. Increased production can and will be achieved by new planted area and new production systems but both of these solutions also create a level of financial risk to apple growers. I think we also need to focus on the improvements that can be made through the identification, understanding and management of within block tree to tree variability on both existing block and potential new plantings. Minimising variability is really about attention to detail through the entire life of a tree. All businesses need to focus on continuous improvement to ensure on-going financial sustainability. Minimisation of tree to tree variability is part of the continual improvement model. The solutions to improved variability are likely to also improve in market acceptance through decreased fruit quality variability as well as increasing the efficiency of us of resources such as land area, fuel, water and other on orchard inputs.

Recommendations

Solutions for measurement of variability need to be able to be practical and cost effective. The output results need to provide growers with information that can quantify the different types and levels of variability that exists within an orchard population as well as the potential financial impact that each group is having. Management decisions are then able to be created as to the level of commitment require to address the problem.

Using trunk diameter to measure the tree to tree variability that currently exists in a specific block of apples is likely to one of the tools that can be used for measuring this problem. Financial modeling reports such as “Block Analysis” on OrchardNet® are also likely to be part of the solution to defining the cost of the tree to tree variability.

Finding solutions to the limiting factors that have caused within block variability in many cases is likely to be easier than the quantification and qualification of the variability. Growers need to understand how much variability exists and how much this is costing before they will try to look for solutions.

Overall production optimisation will not be achieved within apple orchards until a specific focus is made on measuring, managing and reducing the tree to tree canopy variability that naturally exists in current commercial situations.

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