2010 Annual ARGOS Sector Report

KIWIFRUIT

Compiled by Jayson Benge

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Executive summary

The Agriculture Research Group On Sustainability (ARGOS) is investigating the environmental, economic and social characteristics of primary production systems in NZ with the goal of assessing the sustainability and resilience of farming. In the Kiwifruit sector, the three main production systems are being compared i.e. Hayward grown under integrated management ('Green'), Hort16A grown under integrated management ('Gold') and Hayward grown under certified organic management ('Green Organic'). This report describes the main features of these and the differences between them.

Production trends

- Since 2004, Gold orchards in the ARGOS programme have produced significantly more and larger fruit than the Green and Green Organic orchards. The Green orchards have on average produced a third more trays than their Organic counterparts; the Organic orchards have also tended to produce smaller fruit.
- In terms of fruit dry matter levels, overall for the 2006-2010 period there was no statistical difference in average Taste ZESPRI Grade (TZG) between the ARGOS Green, Green Organic and Gold orchards.
- The production trends for ARGOS orchards have generally followed Industry trends.

Orchard history and management

Owner involvement

The majority of ARGOS orchards have tended to fall into the owner-operated category with the owners spending a lot of their time on the orchards and performing work effectively 'unpaid'. That said the time consuming task of canopy management is often performed by paid labour.

A greater proportion of the ARGOS Gold orchards would fall into the managed category i.e. fewer of their owners have performed significant amounts of tractor work (i.e. mowing and spraying) and pruning. More of the ARGOS organic owners have lived on their orchards.

Canopy management

- More Green Organic orchardists in ARGOS have preferred to use low vigour wood compared to their Green counterparts.
- The percentage of Gold orchardists with a preference for replacement cane has been significantly higher than that for Green although the number with a preference for low vigour has not differed. A significantly lower proportion of Gold orchardists said they used a mixture of wood.

Pollination

- The number of hives per ha on average has not differed significantly between ARGOS's Green, Green Organic and Gold orchards (average ~ 8.3 / ha).
- About a third of the ARGOS orchards have used artificial pollination each year with a significantly lower proportion of Gold using it.

Girdling

Overall trends:

- The percentage of ARGOS orchardists that practice trunk girdling has generally increased.
- In 2009/10, the proportion of Hayward orchards (Green and Green Organic) double trunk girdled decreased while the proportion single trunk girdled increased compared to the

previous year. This is evidence that Hayward orchardists have become cautious about the use of double trunk girdling. In contrast the number of Hort16A orchards double trunk girdled increased in 2009/10.
- There has been a general trend for trunk girdling to replace cane girdling.

Panel differences:
- Averaged across all years, significantly lower percentages of Green orchards have been girdled, cane or trunk, compared to their Gold counterparts. Green Organic has been intermediate to these.
- The percentage of orchardists that have trunk girdled (single or double) has been consistently highest for Gold and consistently lowest for Green, with Green Organic intermediate. Overall, the differences between all three were statistically significant.
- The percentage of orchards double trunk girdling has not differed significantly overall.

Nutrition

- Gold and Green orchards have applied the same amounts of macro-nutrients (i.e. not statistically different).
- Organic orchards have received statistically less nitrogen (N), potassium (K), magnesium (Mg) and sulphur (S) but similar amounts of phosphorus (P) and calcium (Ca). Organic orchards tend to receive large quantities of plant and animal based fertilisers like compost and fish.
- Lime, Sulphate of Potash (SOP; potassium sulphate), Muriate of Potash (MOP, potassium chloride), and Calcium Ammonium Nitrate (CAN) are the most commonly applied mineral fertilisers for Green and Gold. SOP is also commonly applied to Organic orchards as are RPR and Patent Kali.

Sprays

- The average number of each of the main types of crop protection and budbreak sprays applied to orchards has not changed greatly over the last 10 years. However, there has been a move towards sprays which are less toxic.
- Organic orchards typically do not apply any chemicals for budbreak, or for weed or fungus control. However, they apply statistically more insecticides although these tend to be less toxic overall.
- Historically the majority of conventional sprays have been applied after fruitset. However, in recent years there has been an increased effort by Industry to promote pre-flowering use of sprays on conventional orchards so that any chemical residues on fruit are minimised.

Other practices

- Organic orchards on average have been mowed and mulched statistically fewer times each year.
- In the last couple of seasons, a third to a half of ARGOS orchards has irrigated to assist vine growth and health. Close to half the orchards have also used some form of frost protection. Only one or two orchards have carried out any form of soil cultivation which is a reflection of the good quality soil on which the majority of orchards are grown.

Environmental outcomes

In previous ARGOS publications and reports like this a number of significant differences have been reported in measured environmental variables. Generally, organic orchards have been found to have better soil quality and biodiversity. However, this is not to say that the environment in conventional orchards is not good.

Cicadas

- Cicadas were sampled for a sixth consecutive year in 2010. Green orchards have consistently had the most shells per vine trunk, Gold the least and Green Organic intermediate. Overall, these differences have been statistically significant.
- Two main species are found almost exclusively on NZ's kiwifruit orchards i.e. *Amphipsalta cingulata* (Clapping Cicada) and *A. zelandica* (Chorus Cicada). The ratio of these on orchards depends on altitude i.e. the proportion of clapping cicada increases and the proportion of chorus cicada decreases as altitude increases.

Birds

- Birds were surveyed for the third time in 2009/10. Overall, introduced species were much more abundant (per hectare) than native species. The only significant differences found were for native species with all native species and native insectivore species being higher for organic orchards than for conventional orchards.

Soils

Fertility

In 2009 and 2010 soil quality was assessed on all the ARGOS orchards for a third time (previous rounds of sampling occurred in 2004 & 2006). On average across the three sample points, soil quality has been found to be good for all three production systems i.e. the levels of individual soil properties were in the medium to high ranges used.

Organic was the most different having on average significantly higher levels of pH, cations (Ca, Mg & K), cation exchange capacity (CEC), total base saturation (TBS%), carbon (C) and nitrogen (N), but lower levels of sulphur (S) and phosphorus (P). On the whole, Gold compared to Green had higher average values for many soil chemistry measures.

Two different areas have been sampled in the ARGOS orchards. Generally, soil pH, CEC, cations, TBS%, C and N were higher in the between-row areas but P levels were lower, compared to the within-row areas.

Microbiology

At the time of preparing this report the results of microbiological analyses on samples collected in 2010 were not fully completed. Previous results from 2004 and 2006 provided evidence of greater amounts of microbiology in organic soils. However, there was no evidence of greater microbiological activity i.e. basal respiration did not differ. The soil of Green and Gold orchard did not differ in their microbiology.

Economics

Analysis of seven years of financial data (2002/03 to 2008/09) for the ARGOS orchards has revealed the following:

- Gold orchards have had significantly higher Gross Orchard Revenues, Orchard Gate Returns, and Cash Orchard Expenses than Green and Green Organic orchards.
- The only expense category that differed significantly between panels was cash labour which was significantly higher for Gold.
- Due to considerable variation between orchards and small sample size, we lacked the statistical power to be able to conclude if there were any differences in other financial operating variables including cash orchard surplus.
- This work highlights the difficulty in getting a sufficient amount of good comparable financial data to identify any differences that might exist in the financial bottom lines of different production systems.

Capital indicators

The capital based approach argues that for future generations to be as well off as the present then the capital base should at least be maintained. ARGOS has found a number of significant differences for different measures of capital. These included human-made capital (i.e. land & buildings, plant and machinery) and natural capital (e.g. soil quality and biodiversity). However, there is no right or wrong level for many of these. What is more important is change over time. For most measures, remaining consistent or increasing over time is more important than the current level. For example, many of the social capital measures like voting participation should remain the same over time, if not increase. Having said that, there are some measures that need to remain constant or decrease, e.g., greenhouse emissions. Similarly, many of the natural capital measurements are likely to have an 'ideal' range at which they should fall between (to ensure that deterioration is not occurring in the natural environment).

Social research

An analysis of all the social data collected by ARGOS to date (ex. 2010 retrospective interview data) has revealed the following differentiations between the three panels of orchardists i.e. Green, Green Organic ('Organic') and Gold.

- Orchardists' view of what good farming entails: Organic - promote biodiversity over tidiness on property, reduce production gap with non-organic orchardists; Green - maintain tidy orchard, remain economically viable; Gold - pursue innovation and achieve leading production indicators.
- Breadth of view: Organic - broader environmental and social scales of reference relative to management. Environmental positioning: Organic - greater level of engagement with environment and more proactive response to environmental health.
- Feedbacks: Organic - biodiversity favoured over production; Green - look (tidiness) of orchard favoured over production; Gold - production emphasis and more frequent reference to performance of vines.
- Management approaches: Organic - family orientation and collaborative knowledge and skill development; Green - income orientation, with orchard as investment; Gold - business orientation, with attention to productivity and financial bottom line.
- On- and off-farm relationships: Organic - broader view of community, but also greater tendency to self-reliance; Green - greater confidence in and reliance on ZESPRI to reduce uncertainty, reflected in greater aversion to independent risk taking; Gold - more managers, who tend to separate orchard management from off-farm relationships.

An analysis of drivers for environmental sustainability in the New Zealand Kiwifruit Industry, performance and possible responses

This report finishes with an outline of why environmental sustainability is important and why the NZ Kiwifruit Industry could benefit from being proactive in this area. The following recommendations for advancing the sustainability of the Industry are discussed:

A. Increase Strategic Focus
B. Increase Responsiveness to Complex Market Signals
C. Grow Organics – A Possible Flagship and Resource for the Industry?
D. Maintain or Enhance Investment in Sustainability Research
E. Attain and Communicate Clear Signals for Greater Grower and Industry Support
F. Establish Collective Responses
G. Maintain or Strengthen Community Relationships

Preface

ARGOS was formed at the end of 2003 with work beginning in earnest in 2004. The first Annual ARGOS Sector Report for Kiwifruit was produced in 2005 and contained findings from the first 12 – 18 months of the programme. The following annual reports presented the results of subsequent research. This instalment focuses on findings from the last 12 months i.e. 2009/10.

Full reports for much of the content in this report are available from ARGOS; many can be downloaded freely from www.argos.org.nz

Every effort has been made to ensure that all the information within is accurate. However, if there are any errors, please let us know as soon as possible so that we can correct our data for future analyses.

If you have any questions about the content of this report or other ARGOS reports, please contact:

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The ARGOS programme has been designed and implemented with the intention of providing quality information to both farmers and orchardists and their associated industries to ensure that they are broadly sustainable, internationally competitive and profitable. To facilitate this we greatly value the involvement of all the participants and industry partners.

A number of ARGOS staff and affiliated researchers have contributed content to this report and this is gratefully acknowledged.

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1. Introduction

1.1 ARGOS

ARGOS stands for the **A**griculture **R**esearch **G**roup **O**n **S**ustainability and is an unincorporated joint venture between Lincoln University, The University of Otago and The Agribusiness Development Group Ltd.

ARGOS is undertaking a longitudinal study, called "Pathways to Sustainability", which is determining the environmental, economic and social characteristics of primary production systems in NZ with the goal of assessing the sustainability and socio-ecological resilience of farming. A number of agricultural sectors are involved including kiwifruit, sheep & beef (lowland and high country), dairy and farms owned by Ngai Tahu landowners. ARGOS is also assessing market developments overseas and how these are likely to affect and be implemented in NZ. The costs of implementation and potential benefits of these will be further assessed.

This research, which is funded by the Foundation for Research and Technology (FRST) and Industry, started in 2003 and will run until at least 2012.

1.2 Programme context and market access drivers

Kiwifruit is New Zealand's largest horticulture export industry and a major player in the global market. In 2009, NZ horticultural exports were valued at $3.4 billion with kiwifruit accounting for just over one billion of this (Plant & Food Research, 2009). The success of agriculture in New Zealand, including kiwifruit, is facing continual emerging threats to market access. ARGOS is continually monitoring overseas market access issues and assessing how these are likely to be implemented and what the impact will be to the New Zealand kiwifruit industry e.g. GlobalGAP and changes in the EU Agricultural Policy. The potential benefits and risks of these will be further assessed using the LTEM (the Lincoln Trade and Environment Model developed for government policy and planning). This enables the impact of various scenarios, relating to the level of production and consumption, premiums and production costs, to be assessed both for NZ and other countries.

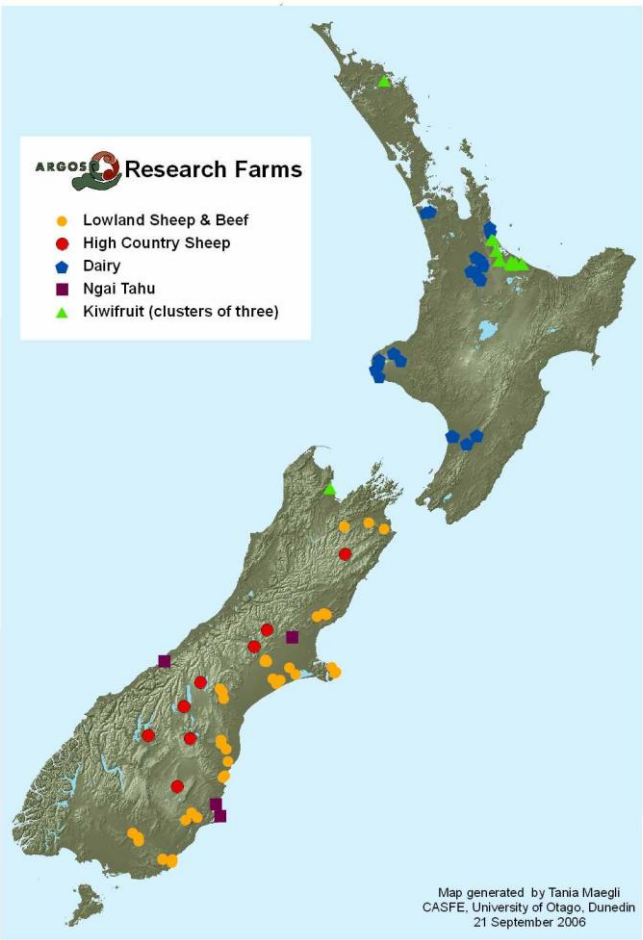
1.3 Kiwifruit research design

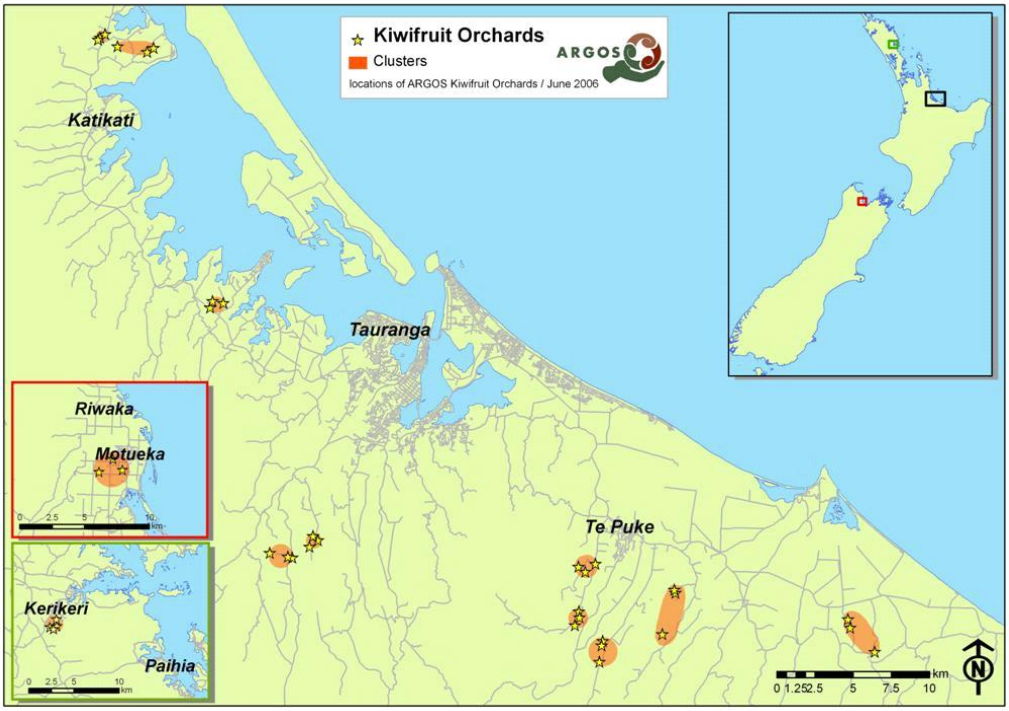
The following production systems (sometimes referred to as management systems or panels) are being studied in the kiwifruit sector by ARGOS:

- Hayward (*Actinidia deliciosa*) variety grown under integrated management ("Green")
- Hayward variety grown under the certified organic system ("Green Organic")
- Hort16A (*A. chinensis*) variety grown under integrated management ("Gold")

Twelve clusters of orchards are being studied with each cluster containing one of each orchard type (36 orchards in totals). The orchards within each cluster are close together to minimise differences in background factors like soil type and climate. Ten clusters are in the Bay of Plenty with one in each of Kerikeri and Motueka (Figure 1). These locations are consistent with the industry distribution of orchards and will potentially allow extrapolation to the wider industry.

Figure 1. Location of ARGOS farms (top) and kiwifruit orchards (bottom) in NZ.





2. Overview of main research activities

ARGOS kiwifruit research activities commenced in 2004. The first major undertaking was a survey of the habitats present on each orchard in 2004 and the creation of detailed orchard maps from this (an example is provided in Figure 2). Since then a number of orchard monitoring events and interviews have occurred (Figure 4) i.e.

- annual interviews with each participant to collect orchard management and input data as well as financial data
- regular social interviews
- regular environmental monitoring with a focus on soil quality and terrestrial biodiversity (particularly birds)

Alongside this a number of reports with a focus on kiwifruit have been delivered to ZESPRI and Industry (Figure 3). These have included annual stakeholder reports which have summarised the main findings each year. A number of other reports have also been produced by ARGOS and these are listed in the back of this report. Further monitoring and reporting is planned for the next couple of years.

Figure 2. Example of orchard map created by ARGOS.

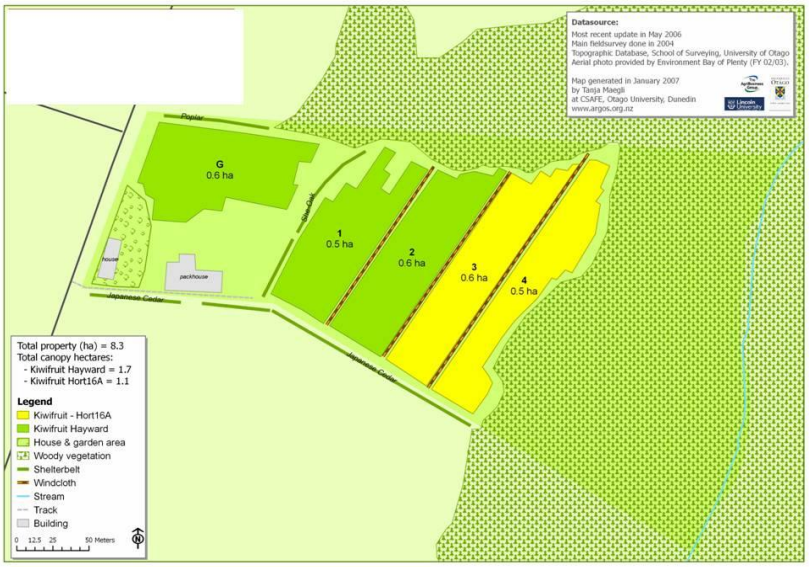


Figure 3. Key ARGOS reports delivered to Industry.

Reports	Delivery responsbility	2004	2005	2006	2007	2008	2009	2010	2011
Annual stakeholder reports	Jayson Benge	■	■	■	■	■	■	■	■
Total energy indicators report	Andrew Barber & Jayson Benge			■					
National farm survey report (attitudes & opinons to sustainability)	Jayson Benge						■		
Kiwifruit environment report	Jayson Benge & Jon Manhire							■	
Soil contaminant reports	Jayson Benge							■	■
Market access update reports	Caroline Saunders				■	■ ■			
Kiwifruit journal articles	ARGOS	■	■		■	■ ■	■ ■	■	
Food miles report	Caroline Saunders			■					

Figure 4. Timeline of main ARGOS field activities in the kiwifruit sector.

Objective	Survey	Responsibility	2004	2005	2006	2007	2008	2009	2010	2011
Management	Annual management interview + collection of financial data	Jayson Benge								
	Annual sector workshop	Jayson Benge								
	Winter bud survey	Jayson Benge								
Environment	Habitat & shelterbelt survey (farm mapping)	Alex Wearing								
	Soils	Jayson Benge								
	Nematodes	Sarah Richards								
	Birds	Biodiversity Survey Team								
	Fantails	Guinevere Coleman								
	Orchard sward survey	Jayson Benge								
	Insect & mite survey	Jayson Benge & David Steven								
	Cicadas (shells)	Jayson Benge								
	Spider (webs)	Jayson Benge								
	Lizards	Jayson Benge								
	Bats	Biodiversity Survey Team								
Social	Qualitative 1 interview (Goals, vision, constraints, production issues)	Lesley Hunt								
	Qualitative 2 interview (Constraints/enablers)	Lesley Hunt & Chris Rosin								
	Qualitative 3 interview (Resilience)	Lesley Hunt & Chris Rosin								
	Causal mapping 1 (Understanding orchard systems)	John Fairweather								
	Causal mapping 2 (Changes to orchard systems)	Jayson Benge								
	National farm survey 1 (Attitudes & opinions)	John Fairweather								
	National farm survey 2 (Attitudes & opinions)	John Fairweather								
Economics	Lincoln Trade & Environment Modeling	Caroline Saunders	Ongoing							
	Market access watch	Caroline Saunders	Ongoing							
	Analysis of financial data	Glen Greer and Jayson Benge	Ongoing							

3. Orchard production

3.1 Introduction

This section of the report provides average export production data for the Green, Green Organic and Gold orchards in the ARGOS programme as well as average Industry data. This information is designed to illustrate key production differences between ARGOS orchards and between management systems. It is hoped that with time, we will be able to contribute to a better understanding of what might be contributing to these differences. Differences are likely to be due to a combination of environmental, financial and social factors, all of which are addressed in the transdisciplinary approach adopted by the ARGOS programme. Industry data presented here was obtained from ZESPRI databases and publications.

3.2 Number of trays

The performance of individual orchards is often measured in terms of its yield particularly the number of export trays produced. Orchardists often benchmark their yields against neighbours, other orchardists, and packhouse/industry averages. Trends for the ARGOS orchards are shown in Figure 5 and are summarised as follows:

- Since 2001, the average no. of trays for ARGOS panels has increased:
    - On average Green orchards have increased their production each year by about 250 trays / ha.
    - On average Green Organic orchards have increased their production each year by about 320 trays / ha.
    - On average Gold orchards have increased their production each year by about 600 trays / ha.
- Overall between 2001 and 2010, the Green Organic orchards in the ARGOS programme produced significantly fewer trays per hectare than the Green and Gold orchards i.e. 5,800 trays / ha vs. 7,700 and 8,800 trays / ha respectively. These differences were statistically different ($P < 0.001$).
- Since 2004, ARGOS Gold orchards have on average consistently produced more trays per hectare than Green. The averages between 2004 and 2010 were 10,000 vs. 8,100, which was statistically significant ($P < 0.001$) (Table 1). Prior to that yields were similar because the Gold canopies were still developing.
- Trends in average tray numbers for the ARGOS panels have mirrored industry trends.

The increases in tray numbers is likely the result of improved practices and technology transfer. Girdling is an example of a relatively new practice which is used to increase fruit quality but also has the effect in Hayward of increasing return bloom and potential yield in the following season (this increase is not always desirable as it can result in the need for increased thinning (and cost), and potentially reduced fruit size due to a dilution effect). Differences in inputs particularly the lack of hydrogen cyanamide is a significant factor for less production on Organic orchards.

3.3 Fruit size

Fruit size is another important measure of orchard production as consumers and markets have preferred sizes. Orchardists strive to maximise yields of preferred size. Trends for the ARGOS orchards are shown in Figure 6 and are summarised as follows:

- The average size of fruit from conventional ARGOS orchards has been similar to Industry averages with the trends across time also being similar. The average size of fruit from organic ARGOS orchards has tended to be smaller than Industry averages.
- The 2005/2006 season was an anomaly for Hayward fruit size which was significantly bigger than other years.
- Overall, the fruit size for ARGOS Gold and Green Organic did not change much between 2001 and 2010. In contrast, Green fruit size appeared to increase slightly.
- Overall between 2001 and 2010, the ARGOS Gold orchards produced significantly larger fruit than Green i.e. average count sizes of 32.2 vs. 34.0. Green Organic produced the smallest fruit i.e. average count size of 35.7. All these differences were statistically different ($P < 0.001$) (Table 1).

3.4 Dry matter

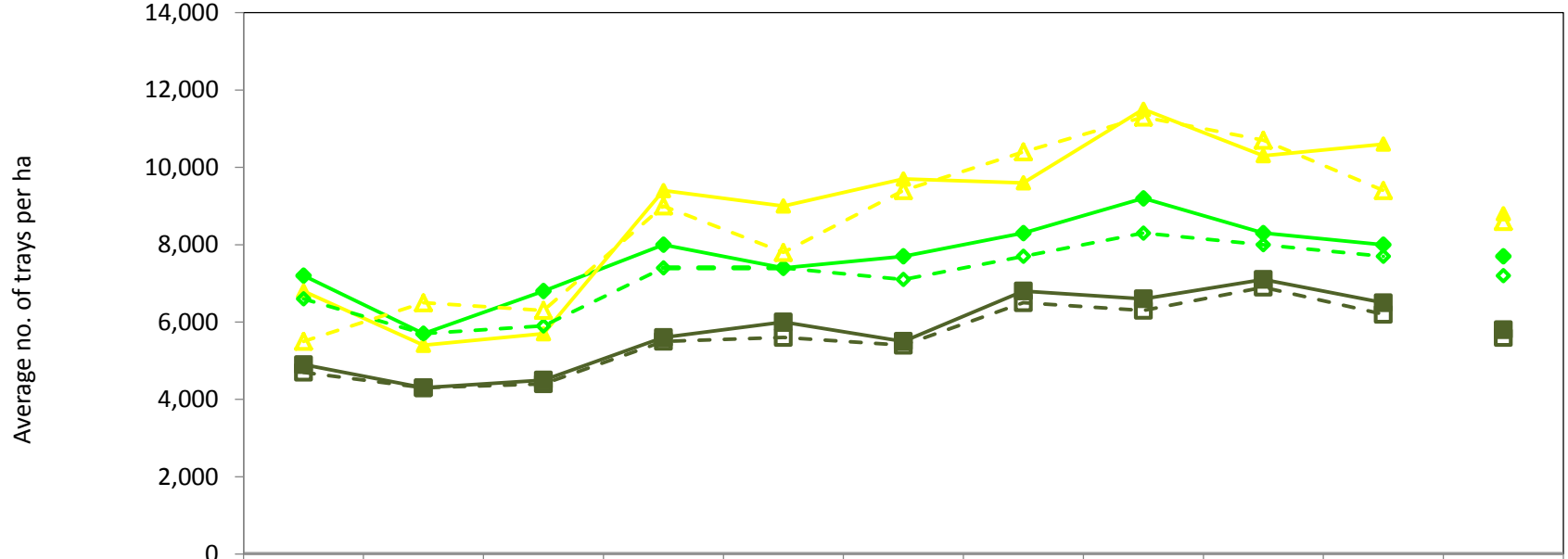
Since about 2002, the dry matter content of kiwifruit has become a dominant measure of orchard performance due to the willingness of consumers to pay more for higher dry matter fruit (= better tasting). For fruit harvested in 2008, 2009 and 2010, the maximum dry matter payments offered for Green, Green Organic and Gold were 40%, 50% and 60% respectively (ZESPRI Grower Premium Booklets 2008-10). Since 2005, the Industry metric of dry matter has been the Taste ZESPRI Grade (TZG) which is a weighted average that takes into account the variation in a sample of fruit. The average trends for Industry and ARGOS orchards are shown in Figure 7. Overall for the 2006-2010 period there has been no statistical difference in average TZG between the ARGOS Green, Green Organic and Gold orchards (Table 1).

Table 1. Summary of export production for ARGOS orchards*.

	Green	Green Organic	Gold	LSD	P-value
Trays/ha (2004-10)	8,100 a	6,300 b	10,000 c	1,400	<0.001
Count size (2001 – 10)	34.0 a	35.7 b	32.2 c	0.8	<0.001
TZG (2006-10)	0.53 a	0.49 a	0.54 a	0.05	0.217

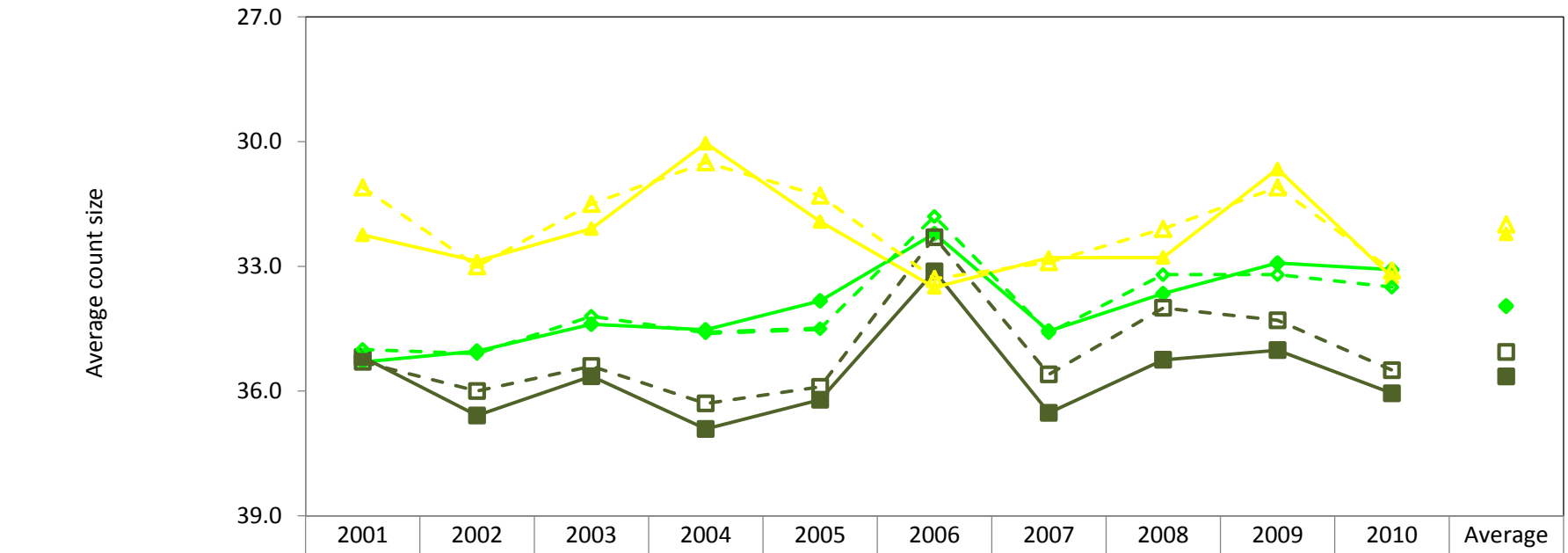
* Data was analysed in Genstat using Repeated Measures ANOVA. System was specified as the Treatment Structure and Cluster as the Block Structure. Within each row, values with the same letters are not statistically different.

Figure 5. Average number of export trays per hectare for ARGOS and Industry orchards between 2001 and 2010.



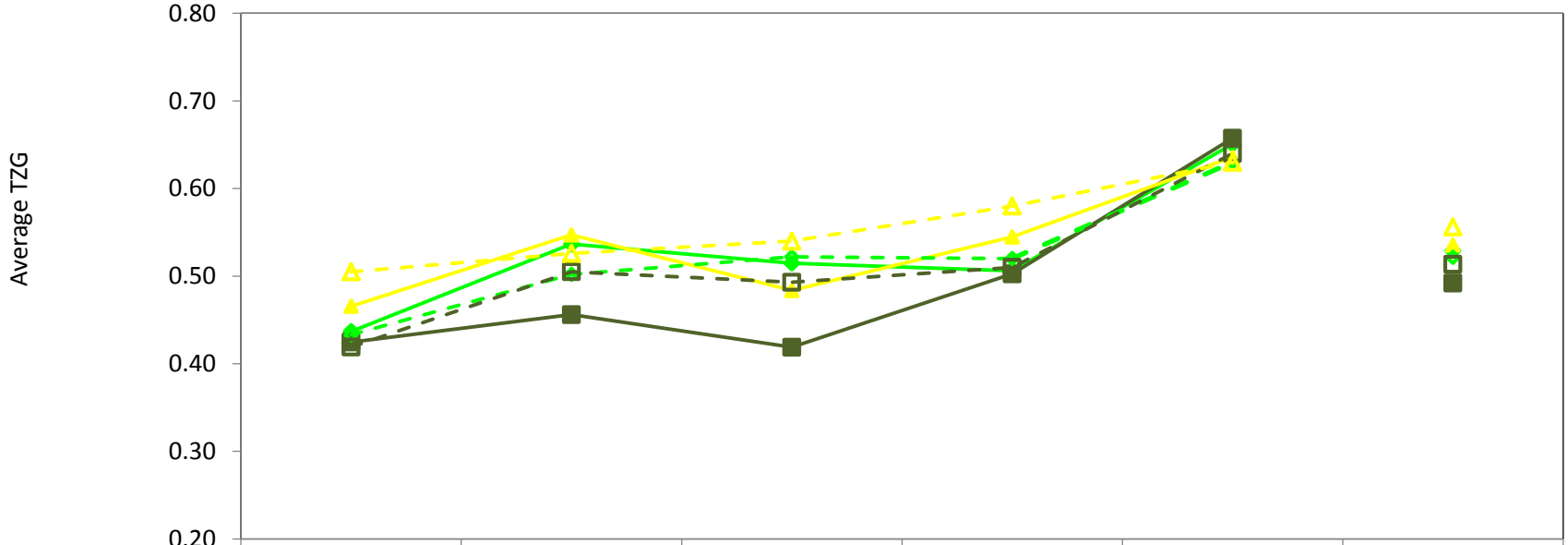
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Average
ARGOS Green	7,200	5,700	6,800	8,000	7,400	7,700	8,300	9,200	8,300	8,000	7,700
ARGOS Green Organic	4,900	4,300	4,500	5,600	6,000	5,500	6,800	6,600	7,100	6,500	5,800
ARGOS Gold	6,800	5,400	5,700	9,400	9,000	9,700	9,600	11,500	10,300	10,600	8,800
Industry Green	6,600	5,700	5,900	7,400	7,400	7,100	7,700	8,300	8,000	7,700	7,200
Industry Green Organic	4,700	4,300	4,400	5,500	5,600	5,400	6,500	6,300	6,900	6,200	5,600
Industry Gold	5,500	6,500	6,300	9,000	7,800	9,400	10,400	11,300	10,700	9,400	8,600

Figure 6. Average count size of export fruit for each ARGOS and Industry orchards between 2001 and 2010.



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Average
ARGOS Green	35.3	35.0	34.4	34.5	33.8	32.2	34.6	33.7	32.9	33.1	34.0
ARGOS Green Organic	35.2	36.6	35.6	36.9	36.2	33.1	36.5	35.3	35.0	36.1	35.7
ARGOS Gold	32.2	32.9	32.1	30.0	31.9	33.5	32.8	32.8	30.7	33.3	32.2
Industry Green	35.0	35.1	34.2	34.6	34.5	31.8	34.6	33.2	33.2	33.5	34.0
Industry Green Organic	35.3	36.0	35.4	36.3	35.9	32.3	35.6	34.0	34.3	35.5	35.1
Industry Gold	31.1	33.0	31.5	30.5	31.3	33.3	32.9	32.1	31.1	33.1	32.0

Figure 7. Average Taste ZESPRI Grade (TZG) for ARGOS and Industry orchards between 2006 and 2010.



	2006	2007	2008	2009	2010	Average
ARGOS Green	0.44	0.54	0.51	0.51	0.65	0.53
ARGOS Green Organic	0.42	0.46	0.42	0.50	0.66	0.49
ARGOS Gold	0.47	0.55	0.48	0.54	0.64	0.54
Industry Green	0.43	0.50	0.52	0.52	0.63	0.52
Industry Green Organic	0.42	0.51	0.49	0.51	0.64	0.51
Industry Gold	0.51	0.53	0.54	0.58	0.63	0.56

* TZG values shown here are weighted averages i.e. for each maturity area, tray equivalents are multiplied by the TZG then all these values are summed with the resulting total divided by the total tray equivalents.

4. Orchard management

4.1 Introduction

Production outcomes, like those discussed in the previous section, will be driven significantly by management. Understanding differences in management on the ARGOS orchards, between and within production systems, will contribute significantly to understanding differences in production as well as other orchard characteristics (e.g. orchard biodiversity, soil quality, financial performance, farming background and attitudes). Here we discuss the recent management factors and practices on the ARGOS orchards and differences between systems. This information has been collected through annual interviews with the orchardists. Other background information about the orchards and orchardists are presented in previous annual reports like this one.

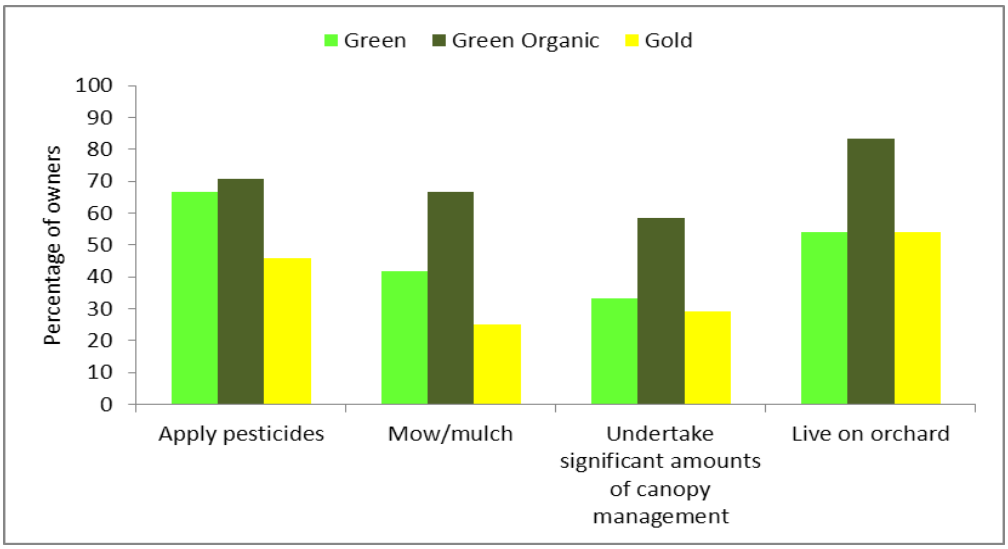
4.2 Management options

Kiwifruit orchardists have a range of management options. These range from having no involvement in the orchard (a leased situation) to having an overseeing role (a managed situation) to having a day-to-day hands-on role (owner-operated). Traditionally, orchards have been owner-operated where the owners (including family) have performed most of the work including mowing, spraying, fertilising and pruning. Anecdotally across Industry, there seems to have been a decline in the number of owner-operated orchards in favour of managed and leased models. This will be in part due to an aging orchardist population.

The majority of ARGOS orchards have tended to fall into the owner-operated category with the owners spending a lot of their time on the orchards and performing work effectively 'unpaid'. That said the time consuming task of canopy management is often performed by paid labour (Figure 8).

A greater proportion of the ARGOS Gold orchards would fall into the managed category i.e. fewer of their owners have performed significant amounts of tractor work (i.e. mowing and spraying) and pruning. More of the ARGOS organic owners live on their orchards.

Figure 8. Percentage of kiwifruit orchard owners in the ARGOS programme who have mowed, sprayed or pruned significant areas of their orchards, and who live on their orchards. Averages for the 2008/09 and 2009/10 season.

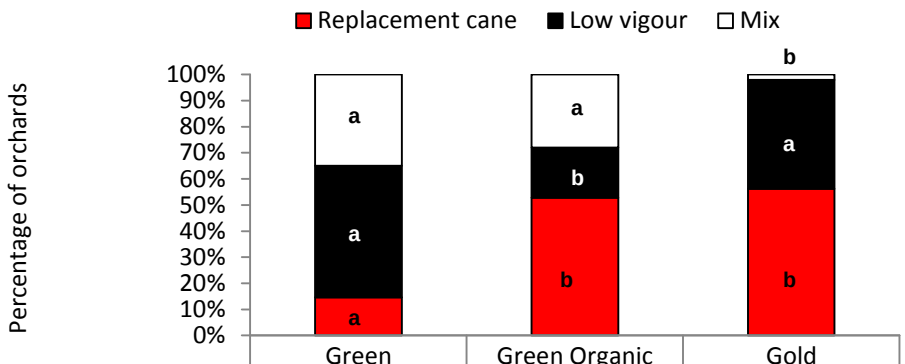


4.2.1 Canopy management

Management of the canopy is the largest annual undertaking on a kiwifruit orchard and for this reason the greatest regular cost. Probably the biggest difference between production systems occurs with the winter pruning of canopy. Winter pruning is the task of replacing last season's fruiting wood with new wood to carry the next season's crop. As organic vines are generally of lower vigour, getting complete canopy fill can be an issue especially at wider plant spacings or following summers during which a lot of replacement wood has been lost to wind, frost or just poor growth. Often greater use is made of more vigourous cane on organic orchards to ensure vines don't "runt out". This is evidenced by the significantly greater proportion of Green Organic orchardists in ARGOS, compared to their Green counter parts, that are using replacement canes rather than lower vigour wood (Figure 9).

In recent years, some Gold orchards have moved away from fruiting on spur wood to fruiting on replacement cane in order to minimise damage to fruit from being so close together on canes. The percentage of Gold orchardists preferring to use replacement cane has been statistically higher than that for Green although the number preferring low vigour wood has not differed (Figure 9). A significantly lower proportion of Gold orchardists said they were comfortable with a mixture of wood.

Figure 9. Percentages of ARGOS orchards (out of 12 for each production system) with each of the different wood preferences*.



	Green	Green Organic	Gold
Mix	35	28	2
Low vigour	50	19	42
Replacement cane	15	53	56

* These are four-year averages (2006/07 to 2009/10) and were verbally communicated to us by the orchardists i.e. no formal assessments were made in the field. For each wood preference (i.e. bar colour), those with the same letters are not statistically different. Data was analysed using an ANOVA with System as the Treatment Structure and Season as the Block Structure.

Summer canopy management is undertaken to ensure next year's fruiting wood remain as well lit as possible through the growing season. It consists mainly of squeezing/tipping of shoots in spring, removal of excess growth in the leader zone, removal of blind unfruitful shoots in the fruiting canopy, removing excessive tangles, and pruning of males after flowering and through the summer as required. Because wood quality is very influential in the floralness of next season's wood, greater attention to the quality of summer canopy work is required in organic production to achieve similar yields as conventional orchards. An important aspect of crop management is thinning or culling of unwanted fruit (or flowers/buds) in order to optimise fruit numbers, size and quality. Most if not all orchards undertake some level of thinning or culling.

4.2.2 Girdling update

Trunk girdling has been used on many horticultural crops around the world for centuries to improve fruit quality, fruit size or fruit numbers. In New Zealand's kiwifruit industry, this innovation has been used commercially since about 2004. Little or no negative impacts have been observed in the short-to-medium term (5 – 10 years) on healthy vines. For this reason, a significant number of orchardists are now trunk girdling and it has very much become standard practice. Some orchardists have yet to girdle for various reasons e.g. they don't believe it's sustainable, the long-term effects are not yet known, the potential risk outweighs the potential benefit, or they don't need to enhance fruit quality or quantity. Furthermore, an important effect of trunk girdling is an increase in return bloom which may be a deterrent for some as additional flowers/fruit may need to be removed in the following season to maintain good fruit size. Greater inputs (e.g. fertiliser, pollination) may also be required to support the extra load. This all comes at a cost.

The size of the effects of trunk girdling depends on its timing. Generally, the biggest improvement in fruit size comes from a spring girdle while a summer/autumn girdle is best for enhancing dry matter. A recent management option has been double trunk girdling (application in spring and again in summer/autumn) to get the best of both worlds.

The main trends in trunk girdling use on ARGOS orchards are shown in Figure 10 and are summarised in Table 2.

Overall trends:

- The percentage of ARGOS orchardists that practice trunk girdling has generally increased.
- In 2009/10, the proportion of Hayward orchards (Green and Green Organic) double trunk girdled decreased while the proportion which single trunk girdled increased compared to the previous year. This is evidence that Hayward orchardists have become cautious about the use of double trunk girdling. In contrast the number of Hort16A orchards which double trunk girdled increased in 2009/10.
- There has been a general trend for trunk girdling to replace cane girdling (Figure 11).

Panel differences:

- Averaged across all years, significantly lower percentages of Green orchards have been girdled, cane or trunk, compared to their Gold counterparts. Green Organic has been intermediate to these.
- The percentage of orchardists that have trunk girdled (single or double) has been consistently highest for Gold and consistently lowest for Green, with Green Organic intermediate. Overall, the differences between all three were statistically significant.
- The percentage of orchards double trunk girdling has not differed significantly overall.
- Up until the 2008/09 season, four ARGOS orchards (two Green and two Green Organic) have never been trunk girdled. However, in the 2009/10 season one of these (Property #19) trunk girdled for the first time in order to advance maturity.

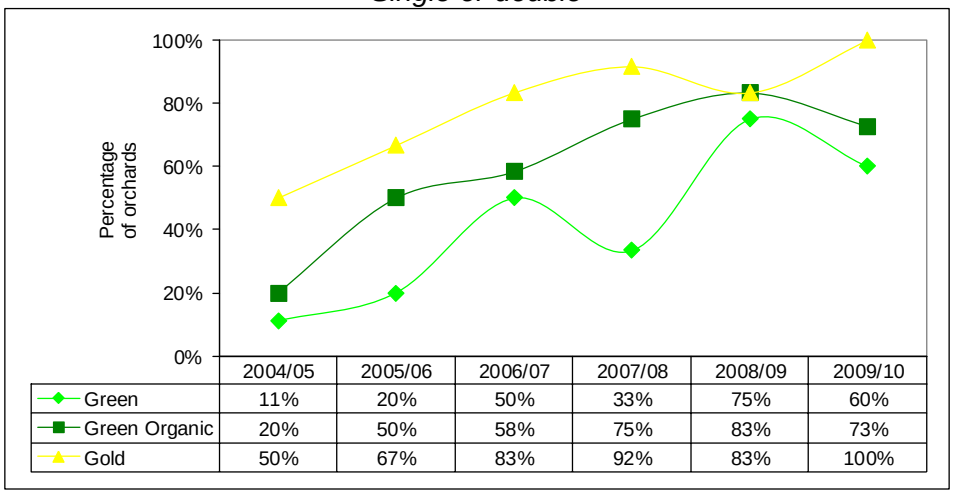
Table 2. Average percentages of ARGOS orchards trunk girdled each year*.

	Cane girdled	Trunk girdled	Double trunk girdled
	2004/05 to 2009/10 period		*2006/07 to 2009/10 period (not done prior to this)*
Green	28 a	42 a	21 a
Green Organic	43 ab	60 b	23 a
Gold	48 b	80 c	33 a
LSD	15	13	22
P-value	0.040	<0.001	0.412

* Within each column, values with the same letters next to them are not statistically different. Percentages trunk girdling each year were analysed using an ANOVA with System as Treatment and Season as Block.

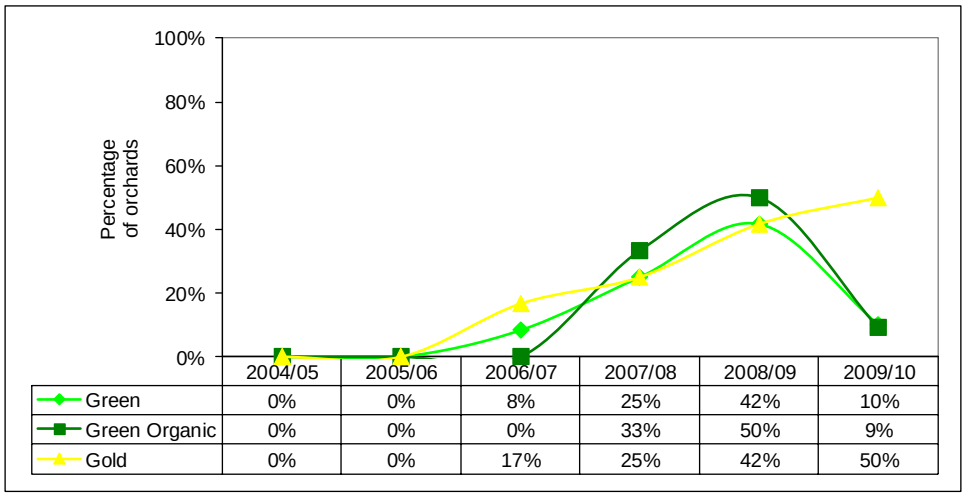
Figure 10. Percentages of ARGOS orchards which have trunk girdled (single or double) each season. 12 orchards of each type surveyed.

Single or double



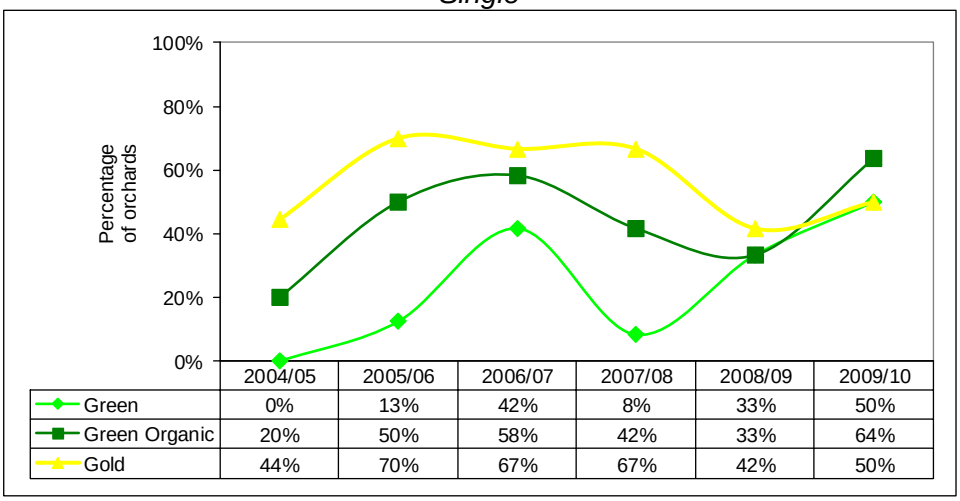
	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10
Green	11%	20%	50%	33%	75%	60%
Green Organic	20%	50%	58%	75%	83%	73%
Gold	50%	67%	83%	92%	83%	100%

Double



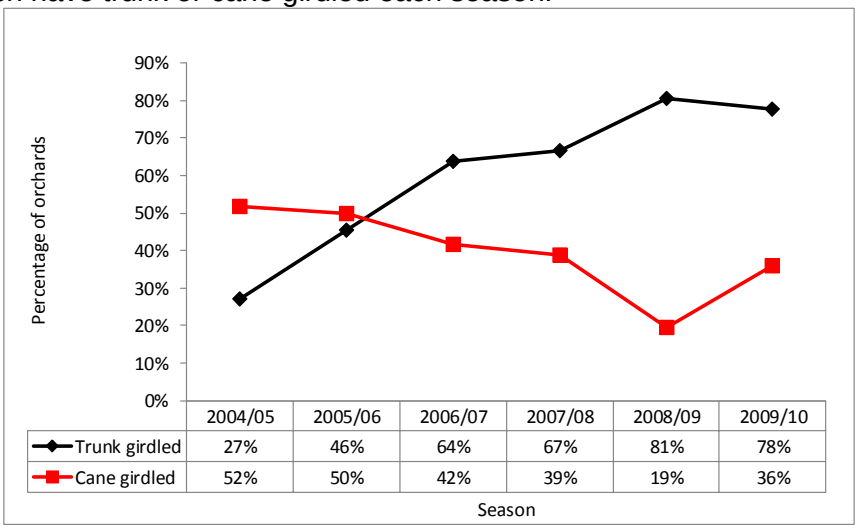
	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10
Green	0%	0%	8%	25%	42%	10%
Green Organic	0%	0%	0%	33%	50%	9%
Gold	0%	0%	17%	25%	42%	50%

Single



	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10
Green	0%	13%	42%	8%	33%	50%
Green Organic	20%	50%	58%	42%	33%	64%
Gold	44%	70%	67%	67%	42%	50%

Figure 11. Average percentages of ARGOS orchards (i.e. 12 Green, 12 Green Organic and 12 Gold) which have trunk or cane girdled each season.



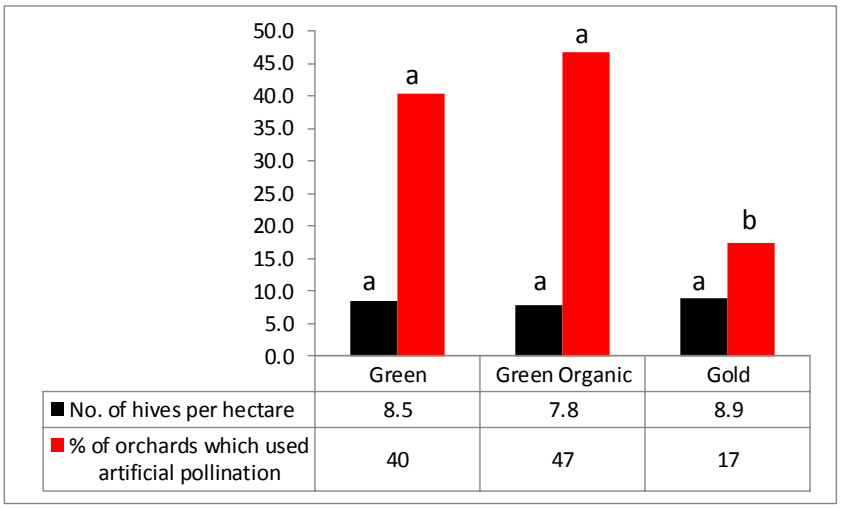
	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10
Trunk girdled	27%	46%	64%	67%	81%	78%
Cane girdled	52%	50%	42%	39%	19%	36%

4.2.3 Pollination

Because kiwifruit require transfer of pollen from male to female vines for fruitset, high stocking rates of specially managed honey bee hives are usually required in orchards. Orchards in high density orchard areas can use less than the recommended eight to ten hives per hectare because of high bee densities on neighbouring orchards with hives. Organic orchards generally flower later (and for a longer period) than their conventional neighbours and may not benefit from this situation.

With the exception of the Organic orchard in Kerikeri, all ARGOS orchards regularly introduce hives to pollinate their fruit with the stocking rates ranging from 6 – 12 hives per hectare. The average number of hives used in recent years has been about 8.4 to the hectare with no significant differences between production systems. About a third of the orchards also have used supplementary (artificial) pollination each year with Gold using significantly less than the other two orchard types (Figure 12).

Figure 12. Average pollination data for Green, Green Organic and Gold orchards in the ARGOS programme. Based on four consecutive growing seasons (2006/07 to 2009/10)*.



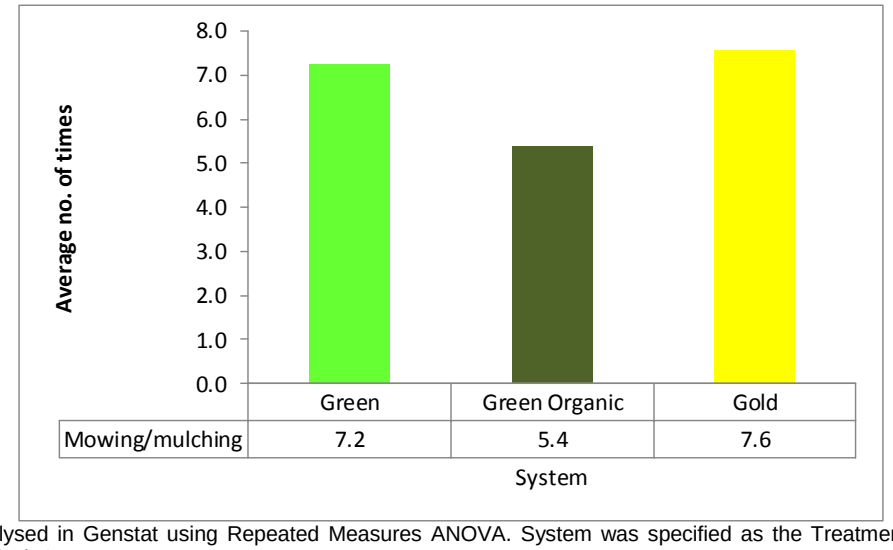
	Green	Green Organic	Gold
No. of hives per hectare	8.5	7.8	8.9
% of orchards which used artificial pollination	40	47	17

* No. of hives/ha was analysed using a repeated measures ANOVA with System as the Treatment Structure and Cluster as the Block Structure. The percentage of orchards using supplementary pollination was analysed using an ANOVA with System as the Treatment Structure and Season as the Block Structure. For each variable, bars with the same letters next to them are not significantly different.

4.2.4 Orchard floor management

Control of the orchard sward in kiwifruit orchards is normally achieved mechanically by mowing. The number of times ARGOS orchards have been mowed in recent years has been relatively constant. Organic orchardists on average have mowed/mulched fewer times each year than Green and Gold orchardists (Figure 13) suggesting that they can tolerate longer sward. This difference was significant (P = 0.004).

Figure 13. Average number of times ARGOS orchards have been mowed/mulched fully each year (2004/05 to 2009/10). Green Organic was significantly lower than the other two*.



* Data was analysed in Genstat using Repeated Measures ANOVA. System was specified as the Treatment Structure and Cluster as the Block Structure.

4.2.5 Sprays

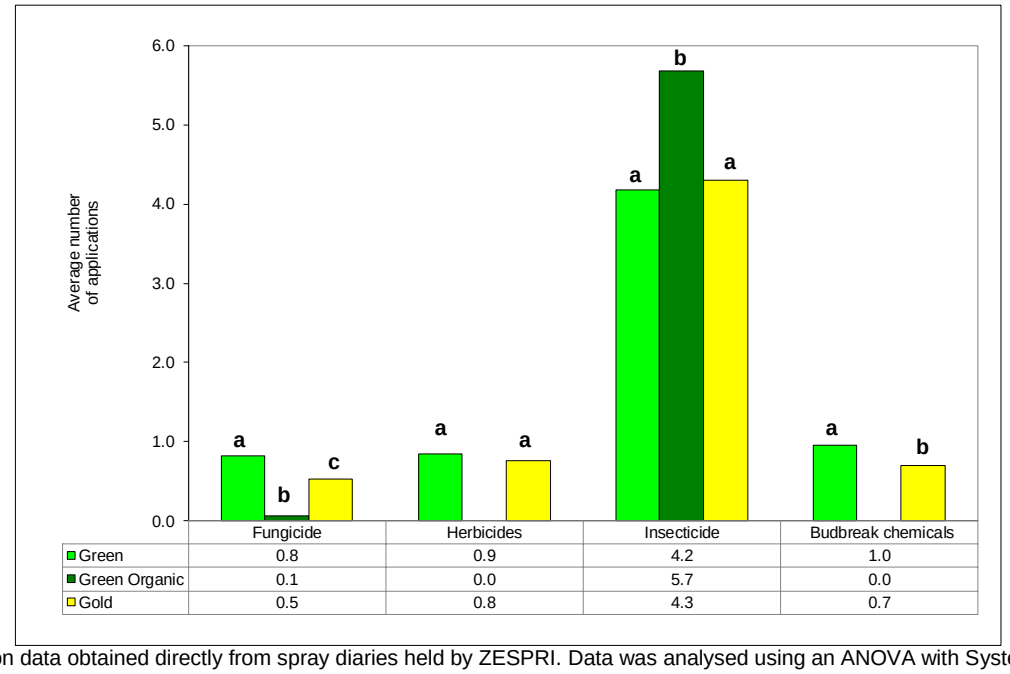
An important aspect of kiwifruit production is the use of agrichemicals to manage animal risks on orchards that might significantly impact on production or the ability to sell fruit. The most commonly applied agrichemicals are for the control of insect pests (Figure 14) particularly leafroller and armoured scale.

The average number of each of the main types of crop protection and budbreak sprays applied to orchards has not changed greatly over the last 10 years perhaps with the exception of herbicides (Appendix 1). However, there has been a shift in recent years to using sprays which are less toxic because of market/consumer pressures.

Organic orchards typically do not apply any chemicals for budbreak, or for weed or fungus control (Figure 14). However, they apply significantly more insecticides although these tend to be less toxic overall.

Historically the majority of conventional sprays have been applied after fruitset (Appendix 2). However, in recent years there has been an increased effort by Industry to promote pre-flowering use of sprays on conventional orchards so that any chemical residues on fruit are minimised.

Figure 14. Average number of times major groups of sprays have been applied annually to ARGOS orchards over the 1999/00 to 2009/010 period*.



* Based on data obtained directly from spray diaries held by ZESPRI. Data was analysed using an ANOVA with System as the Treatment Structure and Season as the Block Structure. For herbicides and budbreak chemicals, Green Organic was excluded from the analysis as none were applied. Within each group, bars with the same letters above them are not statistically different.

4.2.6 Soil nutrition

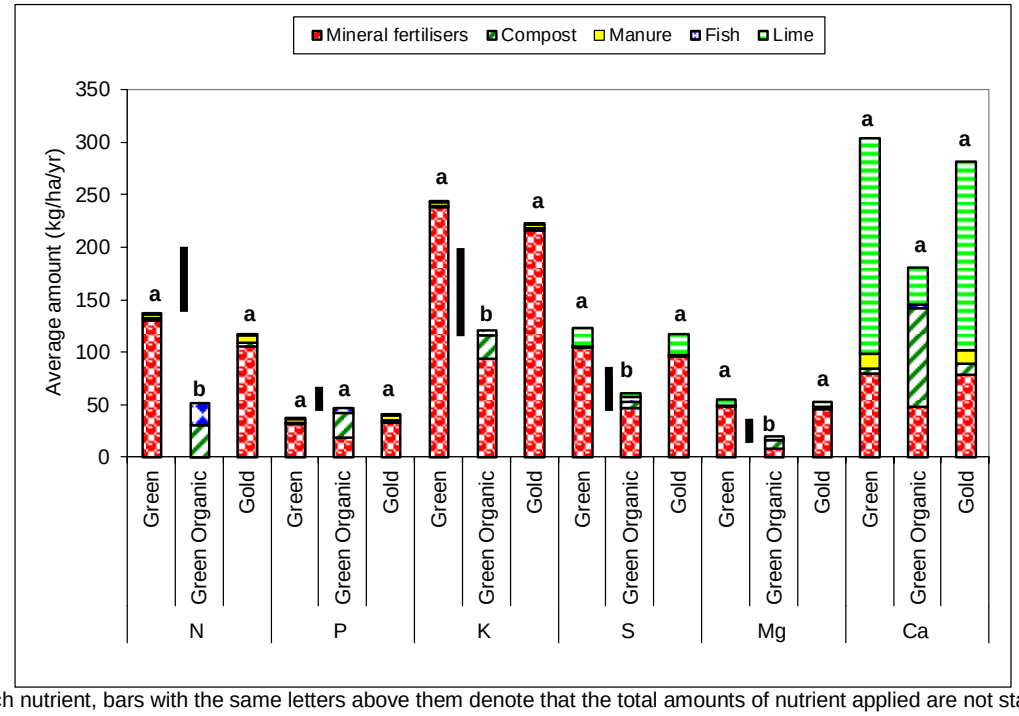
Trends in the levels of macro-nutrients applied to the soil of ARGOS orchards are shown in Figure 16. Average amounts for the 2003/04 to 2009/10 period are shown in Figure 15. On average over the study period and taking into account the variation between orchards, Gold and Green orchards have applied the same amounts of macro-nutrients (i.e. not statistically different).

Over the study period, Organic orchards compared to the conventional orchards have received significantly less nitrogen (N), potassium (K), magnesium (Mg) and sulphur (S) but similar amounts of phosphorus (P) and calcium (Ca). Organic orchards tend to receive large quantities of plant and animal based fertilisers like compost and fish. While the nutritional content of these is small (just a few percent) the large quantities applied (an average of approximately 6.5 T/ha of compost and 1,000 L/ha of fish annually) means potentially large amount of nutrients are supplied. The nutrients in organic fertilisers are likely to be released slowly, over several years.

Lime, Sulphate of Potash (SOP; potassium sulphate), Muriate of Potash (MOP, potassium chloride), and Calcium Ammonium Nitrate (CAN) are the most applied mineral fertilisers for Green and Gold (Table 3). SOP is also applied to Organic orchards as are RPR and Patent Kali.

In the ARGOS programme, Organic orchards were generally found to have soils with slightly better physical and biological attributes while many chemistry measures were also higher in value (Carey and Benge, 2009). Organic orchards were also found to contain significantly less P and S though the levels were still acceptable. Differences in the amounts and types of fertilisers used, as discussed here, will contribute significantly to differences in soil quality; other influential factors include orchard history and previous land use.

Figure 15. Average amounts of macro-nutrients applied to soil in kiwifruit orchards in the ARGOS programme for the 2003/04 to 2009/10 period. The black vertical lines represent suggested annual fertiliser requirements for maintaining yields on established Hayward kiwifruit vines for a 8,000 trays/ha crop (Source: **www.hortnet.co.nz**).



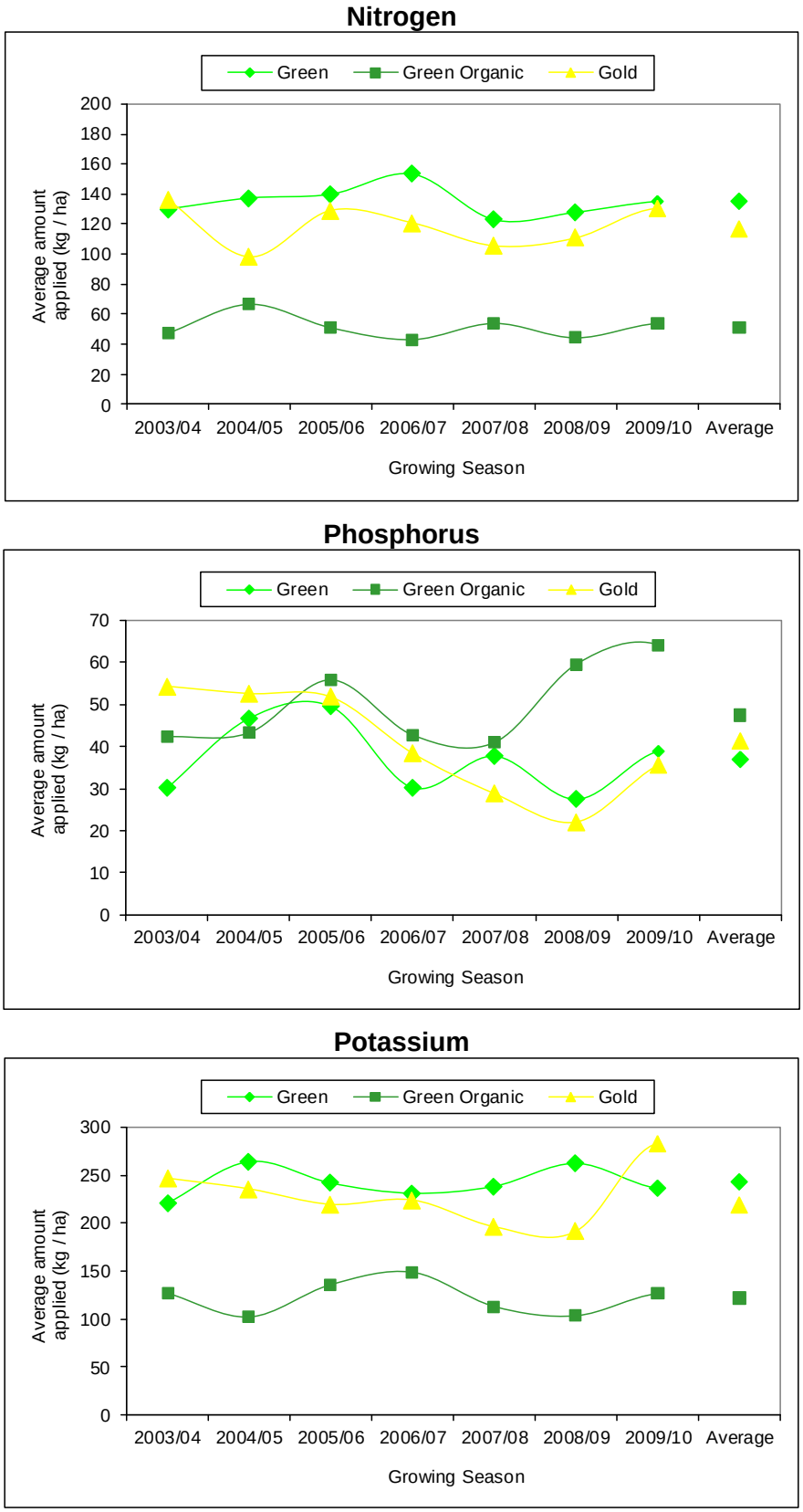
* For each nutrient, bars with the same letters above them denote that the total amounts of nutrient applied are not statistically different. Data was obtained from orchardists' fertiliser recommendations with additional information provided by the orchardists.

Table 3. Most commonly used mineral fertilisers on Green, Green Organic and Gold orchards in the ARGOS programme. Average rates (kg/ha/yr) for the 2003/04 to 2009/10 period are shown*.

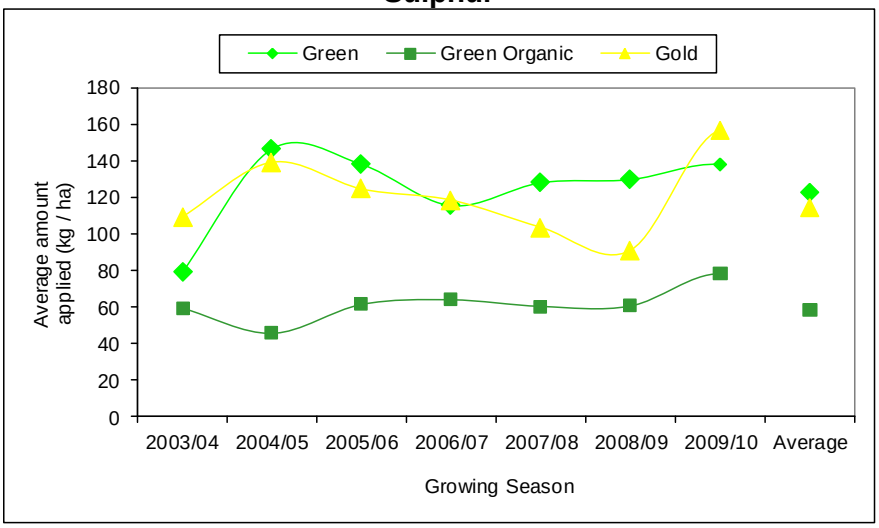
Product	Approx. nutrient content	Green	Green Organic	Gold
Lime	37% Ca	390	60	360
Dolomite	11% Mg, 23% Ca	50	30	40
Gypsum (calcium sulphate)	18% S, 24% Ca	90	20	100
Nitrophoska Blue	12% N, 5% P, 14% K, 6% S	20	0	90
Calcium Ammonium Nitrate (CAN)	27% N, 8% Mg	330	0	200
Urea	46% N	10	0	40
Sulphate of Potash (SOP, potassium sulphate)	40% K, 17% S	260	130	190
Muriate of Potash (MOP, potassium chloride)	50% K	120	30	110
30% Potash Serpentine Super	5% P, 15% K, 6% S, 4% Mg	40	0	110
Patent Kali	25% K, 17% S, 6% Mg	0	60	20
Kieserite	20% S, 15% Mg	80	20	60
Reactive Phosphate Rock (RPR)	12% P	0	100	0

* Generally, data was obtained from orchardists' fertiliser recommendations with additional information provided by the orchardists. A small number of standard kiwifruit mixes, supplied by fertiliser companies, were applied to a small number of orchards. These mixes contained some of the above products however their average contribution (across all orchards) was low and therefore not included here.

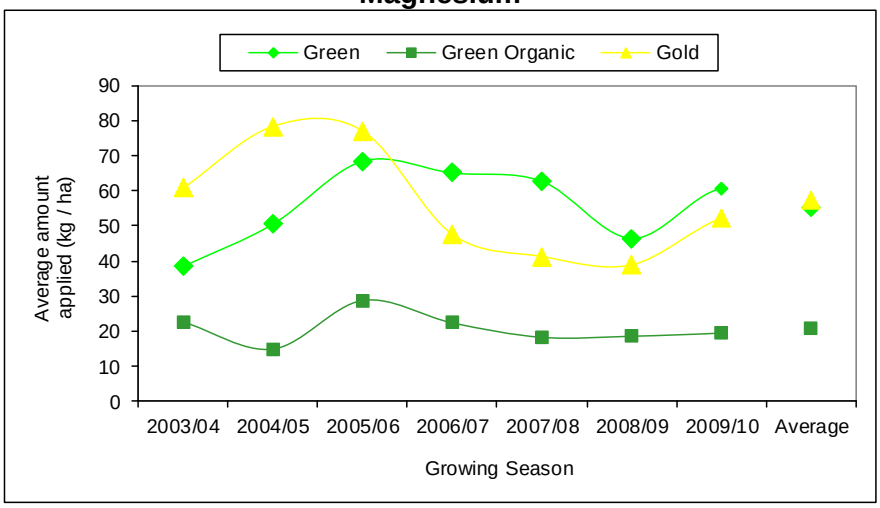
Figure 16. Trends in the average levels of macro-nutrients added to soils in ARGOS kiwifruit orchards between 2003/04 and 2009/10. All types of ground fertiliser are included.



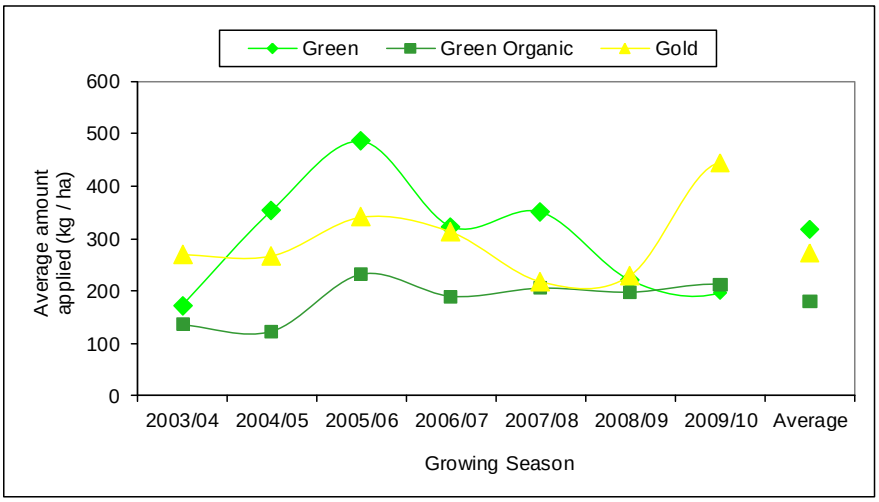
Sulphur



Magnesium



Calcium



4.2.7 Other orchard practices

In the last couple of seasons, a third to a half of ARGOS orchards has been irrigated to assist vine growth and health. Close to half the orchards have also used some form of frost protection mainly in the form of water. We have not been able to quantify water use on orchards as orchardists generally have not able to provide detail on how often water was applied or how much was applied.

Only one or two orchards have carried out any form of soil cultivation which is a reflection of the good quality soil on which the majority of orchards are grown.

5. Environment

5.1 Introduction

Consumers are becoming increasingly concerned about how their food is produced and the associated impacts. This is being reflected in assurance schemes globally which are beginning to place more emphasis on the environmental impacts of farming. Take for example Tesco's 'Nature's Choice' Integrated Crop Management System which encourages the use of beneficial insects rather than chemicals to control pests (http://www.tescofarming.com/tnc.asp). Orchardists are asked to draw up a farm conservation plan, which guides them in protecting important wildlife and landscapes. Closer to home, GlobalGap contains an 'Environment and Management' section which aims to increase orchardist's awareness of the impacts of orcharding on flora and fauna. Requirements like these are likely to increase and for this reason the kiwifruit industry needs to improve its understanding of the impacts of production. The environment objective of the ARGOS programme aims to clarify the environmental impacts of different production systems which will also assist in the identification and subsequent implementation of more sustainable and resilient farming systems.

5.2 Previous findings

The main findings from ARGOS's environmental monitoring have been reported in detail in previous reports like this as well as other ARGOS publications (many of which can be freely downloaded from www.argos.org.nz). Around two-thirds of all measured variables have revealed a statistically significant difference. The main differences are summarised in Table 4.

Table 4. Overall differences between organic and conventional (i.e. integrated management) kiwifruit orchards in the ARGOS programme.

	General finding	**Reference**
Soil quality	Many measures higher for organic orchards although some nutrients lower (sulphur and phosphorus)	Carey and Benge, 2009
Invertebrates	Significant differences in the populations of some insects / mites	Steven and Benge, 2007
	Higher overall biodiversity in organic orchards	Todd et al. 2011 (accepted)
Terrestrial vertebrates	Greater abundance of native species on organic orchards	This report
Orchard habitats	More diverse shelterbelts on organic orchards	Moller, et al., 2007
Aquatic	Not measured (due to lack of waterways on the ARGOS properties)	-

5.3 Most recent findings

5.3.1 Cicadas

Overall findings

Cicadas were chosen as a potential focal species for ARGOS partly because they are classified as a minor pest (adults can cause fruit marking and the eggs are laid in the vines potentially weakening them) and partly as a potential indicator species (they are highly visible, well known and easy to sample).

The amounts of cicada exuviae (shells) attached to the trunks vines in ARGOS orchards have now been determined over six consecutive years. On average, the most cicada shells per vine trunk have consistently been found in Green orchards with the least consistently found in the Gold orchards, and Green Organic intermediate (Figure 17). Overall, the averages have been statistically different from each other (Figure 18).

No associations have been found between altitude or latitude and the average number of cicada shells (all species) on vines across the ARGOS orchards (data not presented).

Species distribution

Two main species are found almost exclusively on NZ's kiwifruit orchards i.e. *Amphipsalta cingulata* (Clapping Cicada) and *A. zelandica* (Chorus Cicada). The ratio of these on orchards has differed with altitude i.e. the proportion of chorus cicada increased and the proportion of clapping cicada decreased as altitude increases (Figure 19).

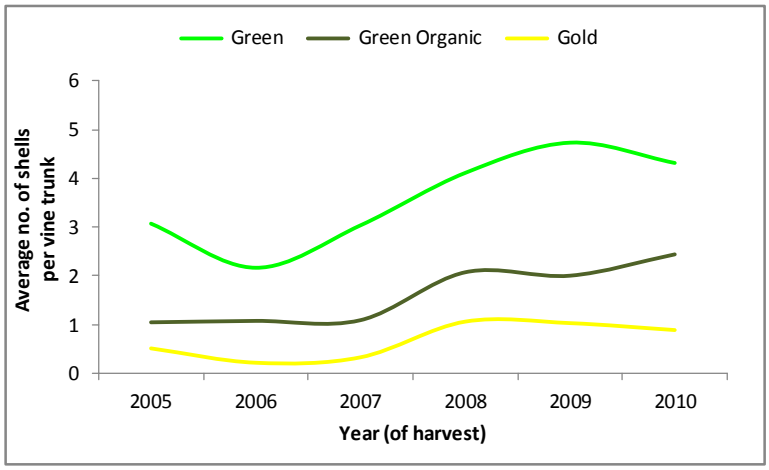
5.3.2 Birds

Birds have now been surveyed three times in each of the ARGOS orchards i.e. once in each the summers of 2004/05, 2006/07 and 2009/10. The average densities for each of the main feeding groups are presented in Figure 20. Overall, introduced species were much more abundant (per hectare) than native species. The only significant differences found were for native species with all native species and native insectivore species being higher for organic orchards than for integrated orchards.

Our analysis has indicated that pesticide use and habitat composition are better predictors of native bird densities in orchards than management system i.e. native bird densities were negatively associated with a pesticide toxicity index[1] we developed and/or positively associated with woody vegetation cover. The implication of this is that while organic orchards support higher densities of native bird species, integrated systems can enhance native bird densities by reducing their use of toxic pesticides and increasing the area of woody vegetation on kiwifruit orchard properties (i.e. complete conversion to organic farming is not required to obtain the observed benefits to native birds). Also highlight that native species are likely more suitable indicators for monitoring the impact of changes in land management practices within the kiwifruit orchards than introduced species. These findings will be discussed more fully in upcoming ARGOS publications.

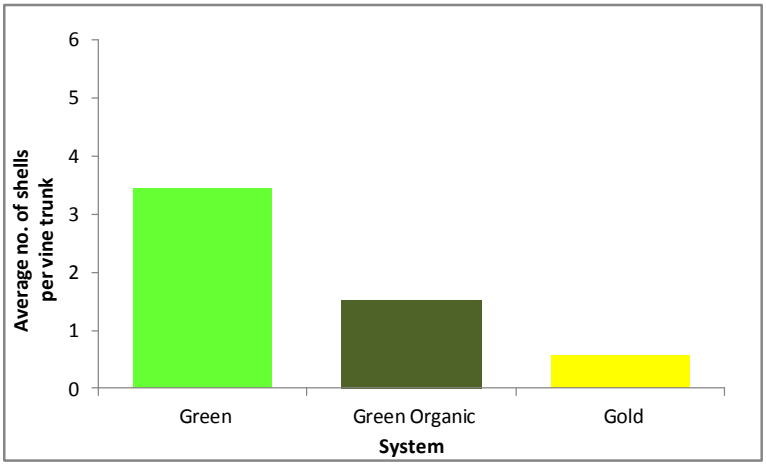
[1] This index will be discussed in more detail in future ARGOS publications

Figure 17. Relative abundance of cicada shells attached to vine trunks in ARGOS kiwifruit orchards in the Bay of Plenty. Approx. 2,000 vines sampled each year*.



* Log back-transformed predicted means shown from repeated measures analysis.

Figure 18. Relative abundance of cicada shells (averaged for the 2005-10 period) attached to vine trunks in ARGOS kiwifruit orchards in the Bay of Plenty. Values shown are all significantly different from each other (P < 0.001). Approx. 2,000 vines sampled each year*.



* Log back-transformed predicted means shown from repeated measures analysis.

Figure 19. Percentages of the two main species of cicada found attached to vine trunks in ARGOS kiwifruit orchards relative to altitude.

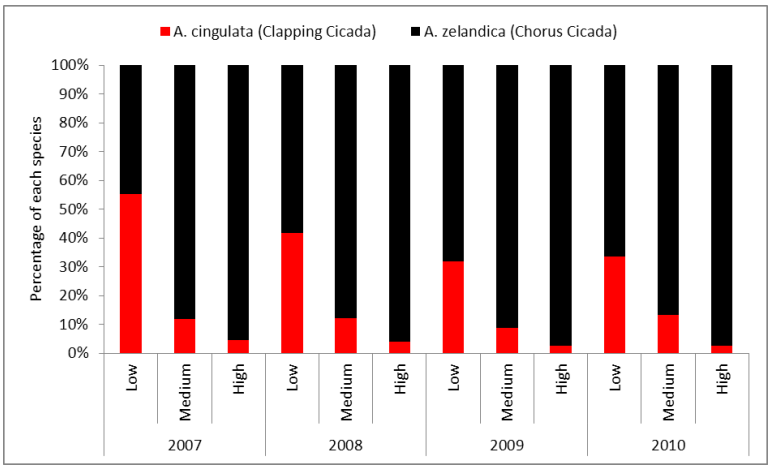
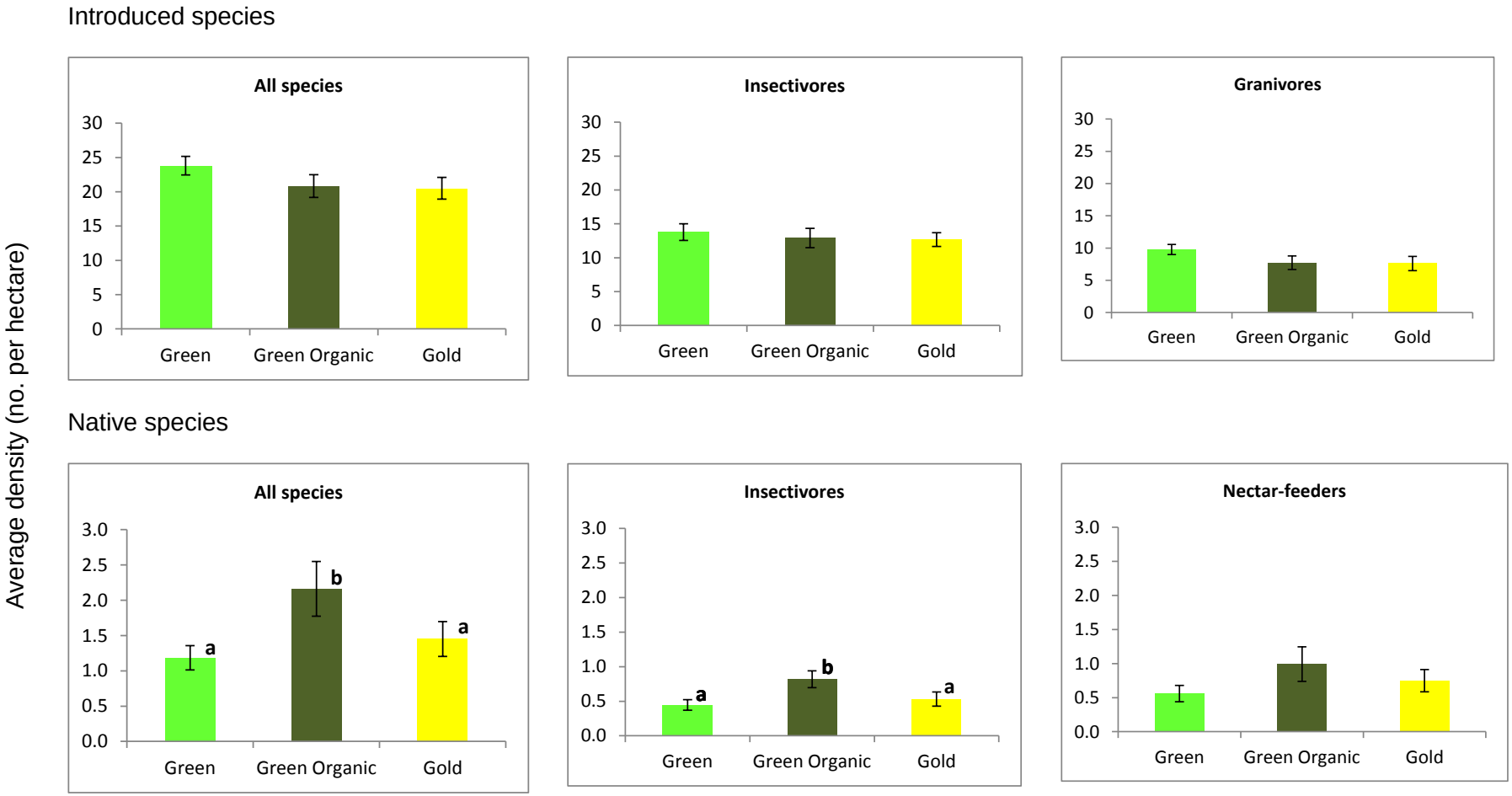


Figure 20. Average densities of birds found in ARGOS kiwifruit orchards. Sampling occurred once in each of the 2004/5, 2006/07 and 2009/10 summers*.



* Error bars represent standard errors. Within a graph, columns with different letters are significant different at the 5% level.

5.3.3 Soils update

Fertility

Overall

In 2009 and 2010 soil quality was assessed on all the ARGOS orchards for a third time (previous rounds of sampling occurred in 2004 & 2006)[2]. On average across the three sample points, soil quality has been found to be good for all three production systems i.e. the levels of individual soil properties were in the medium to high ranges used (Figure 22). The one exception has been Organic S which has been low according to the medium ranges used although these are based largely on pastoral soil samples and may therefore be too high for Bay of Plenty kiwifruit orchard soils.

Panel differences

Organic has been the most different having on average significantly higher levels of pH, cations (Ca, Mg & K), cation exchange capacity (CEC), total base saturation (TBS%), carbon (C) and nitrogen (N), but lower levels of sulphur (S) and phosphorus (P). On the whole, Gold compared to Green had higher average values for the various soil chemistry measures.

Differences within blocks

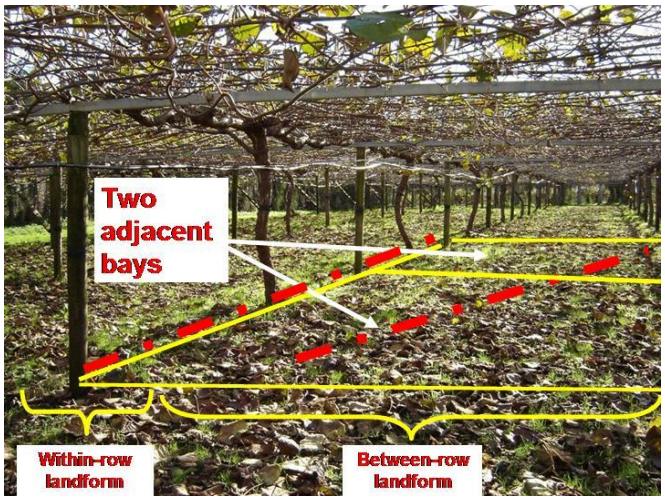
Two different areas have been sampled in the ARGOS orchards (Figure 21). Generally, soil pH, CEC, cations, TBS%, C and N were higher in the between row areas but P levels were lower, compared to the within-row areas (Figure 23).

Significant differences in soil chemistry between production systems and sample areas within blocks for individual years are presented in Appendix 3.

Microbiology

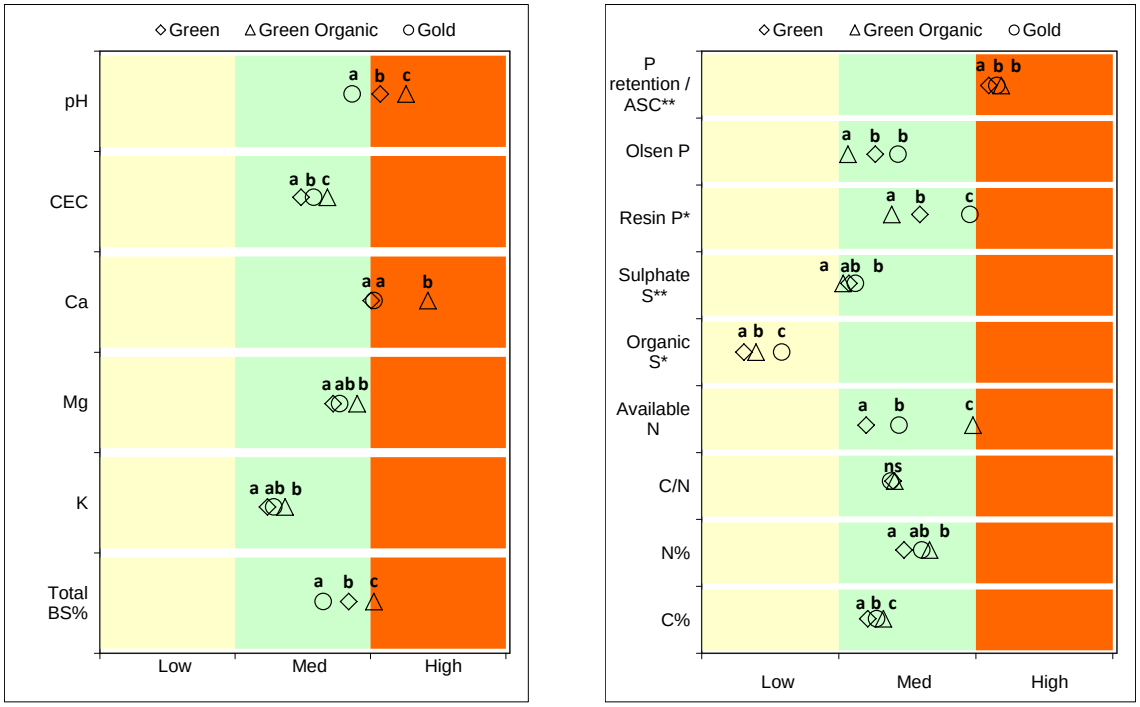
At the time of preparing this report the results of microbiological analyses on samples collected in 2010 were not fully completed. Previous results from 2004 and 2006 provided some evidence of greater amounts microbiology in organic soils (Table 5). However, there was no evidence of greater microbiological activity i.e. basal respiration did not differ. The soil of Green and Gold orchard did not differ in their biology.

Figure 21. Diagram showing the two different areas compared for soil quality within ARGOS kiwifruit blocks. Cores were collected along the dashed lines then sent to labs for analysis.



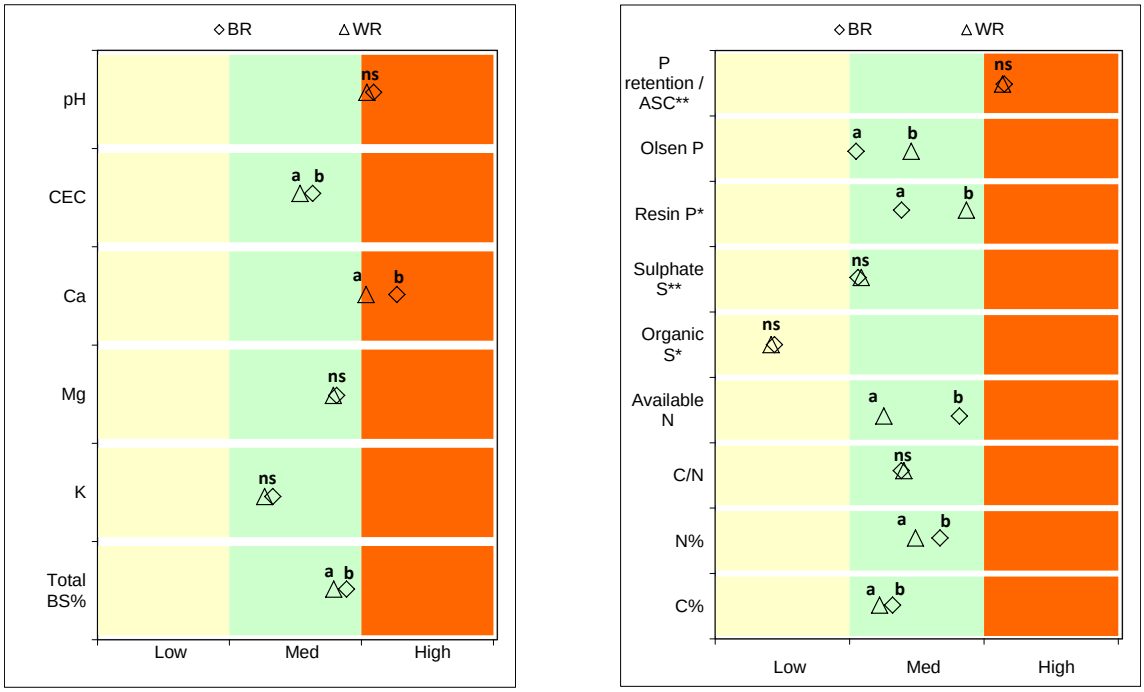
[2] Sampling was split across two years due to unforeseen circumstances delaying the start of sampling in 2009 resulting in sampling not being completed prior to fertiliser applications.

Figure 22. Average soil chemistry properties for soil from ARGOS kiwifruit orchards based on samples collected in 2004, 2006 and 2010. The three ranges specified (low, medium and high) are those used by Hill Laboratories for Kiwifruit*.



* Measured only on 2006 samples; ** Measured only on 2004 & 2006 samples.

Figure 23. Average soil chemistry properties for between-row (BR) and within-row (WR) areas of ARGOS orchards in 2004, 2006 and 2010.



* For each soil property, letters above each symbol denote which ones are statistically different at the 5% level i.e. those which have a different letter are significantly different from each other while those that have a letter in common are not (ns = not significant).

Table 5. Average soil biology values for ARGOS orchards for 2004 & 2006 (Carey et al. 2009).

	Green	Green Organic	Gold
Soluble C** (mg C kg^{-1})	138 a	146 a	154 a
Microbial-N* (mg N kg^{-1} soil)	65 a	93 b	75 a
Microbial-C** (mg C kg^{-1} soil)	356 a	427 b	384 ab
Basal respiration* (mg CO_2 kg^{-1} soil $days^{-1}$)	19.9 a	22.3 a	19.7 a
Metabolic quotient* (mg CO_2 g^{-1} MBC day^{-1})	53 a	48 a	50 a
Earthworms (no. m^{-2})	74a	133b	73a

* Based on 2006 results only as either not measured or different methodology used; ** Based on results from 2004 & 2006.

5.4 Energy return on investment (EROI)

An EROI analysis is essentially a ratio of outputs to inputs. It is a flexible method for measuring the energy cost of energy and is well suited to evaluating the energetic efficiency and intensity of agricultural production systems.

ARGOS estimates of EROIs are presented in Table 6. Although dairy appeared the most efficient in terms of EROI values, we did not have complete energy inputs for our farms and using data taken from Wells (2001) we can conclude that the inclusion of fuel and capital energy costs would increase these by about 50% and would reduce EROI values accordingly, to less than those for KF. Of significance is the low efficiency of energy use for sheep/beef where considerably more energy is expended in inputs than outputs. Generally, more energy is required to produce meat and animal products compared with that for crop or fruit production because of the inefficiencies involved in converting plant feed to animal protein (McMichael et al., 2007). Although the NZ grass-fed animal production system has historically been more efficient than feed-based systems (McChesney et al., 1981), the high tonnages of fruit available from kiwifruit blocks (>20 tonnes/ha) means they have a relatively good EROI. No major differences were evident between production systems within each sector.

Table 6. Median values and ranges in values (in brackets) for energy outputs, inputs and energy return on investment (EROI) for all sector panels*.

Term	Sheep and Beef [1]			Dairy [2]		Kiwifruit [3]		
	Conventional	Integrated	Organic	Conventional	Organic	Green	Gold	Green Organic
Outputs	2.2	1.9	1.6	34.3	15.6	67.6	85.0	51.0
(GJ $ha^{-1}y^{-1}$)	(1.7-2.4)	(1.6-3.0)	(1.4-2.1)	(28.7-38.1)	(12.8-21.6)	(56-82)	(61-114)	(42-60)
Inputs	3.7	4.2	2.8	9.8	6.8	39.3	36.7	26.7
(GJ $ha^{-1}y^{-1}$)	(3.2-4.6)	(3.2-9.0)	(2.2-3.4)	(6.0-11.9)	(3.0-8.6)	(28-47)	(30-54)	(23-32)
EROI ratio	0.36	0.38	0.36	3.5	3.0	2.0	2.2	2.2
	(0.33–0.40)	(0.23–0.56)	(0.25–0.46)	(2.8-4.9)	(2.6-3.9)	(1.5-2.6)	(1.6-3.0)	(1.7-3.0)

[*] Input data based on data primarily from the 2003/04 season while output data based on data for the 2002/3-2008/9 period. Sheep and beef inputs were fertiliser, electricity, supplementary feed, agrichemicals, animal remedies, and capital items including buildings and machinery, fences, and races. Outputs were animals as live weight leaving the farm, wool, and crops harvested; [2] Dairy inputs were fertiliser, electricity and supplementary feed, does not include fuel, agrichemicals and capital items. Outputs were milksolids and cull cows; [3] Kiwifruit inputs were fertiliser, electricity, agrichemicals, and capital items including buildings and vine support structures. Output was kiwifruit.

5.5 Environment summary

A number of significant differences have been found between environment factors of the three main kiwifruit production systems. Generally, the greatest difference has been between Organic and the other two systems with fewer and smaller differences detected between Green and Gold. This is not surprising given that the Organic management system is the most distinct of the three with greater restrictions placed on inputs particularly fertiliser and agrichemical use. Gold is a relatively new variety (commercialised in the late 1990's) and its production system has evolved from the system for Green hence there are some management similarities.

Future monitoring and analysis is planned to see if the differences and similarities we have observed remain or not. As more data is collected then statistical analyses can be carried out to determine the minimal amount of monitoring that would be required to detect trends in environmental outcomes.

6. Financial performance

6.1 Introduction

Details of ARGOS's economic and farm finance monitoring can be found in Saunders, et al., 2009. Here the main findings are presented. At the farm or orchard level, we have now collected financial accounts for seven consecutive years (2002/03 to 2008/09). Each year's data have been analysed to provide information to ARGOS farmers and to compare the performance of these farms with regional and industry benchmarks. This data is also being analysed to determine trends over time, as well as systematic differences amongst farms. The results to date for kiwifruit are presented below.

6.2 Data availability

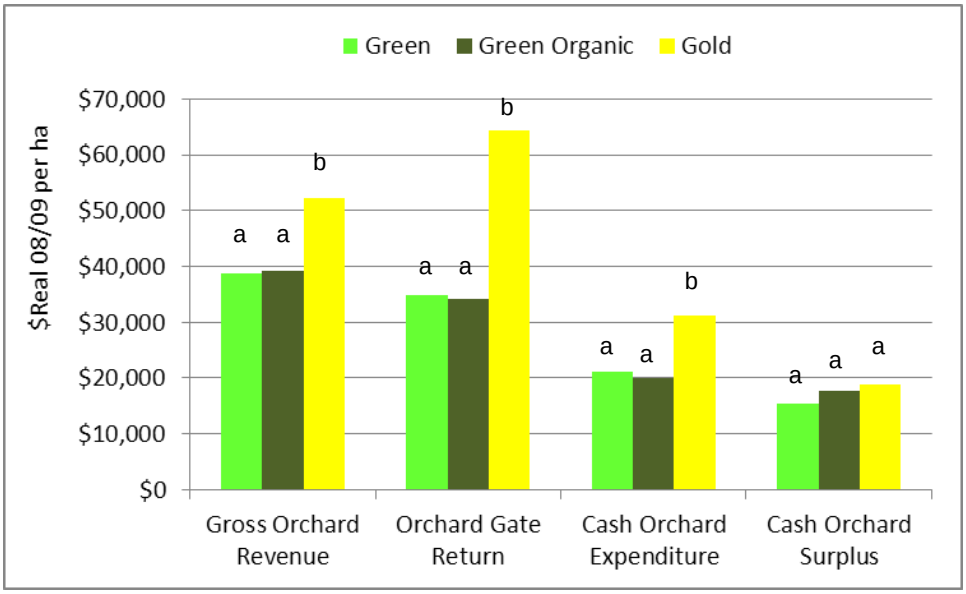
The availability of financial data has been a limitation for the economic analyses in all sectors studied by ARGOS including the kiwifruit sector. For some orchards, data has not been available at all because of the complexity of operations and inability to isolate income and expenditure for the orchards concerned. Gold orchards have been particularly challenging in this respect as some also grow Green (7 out of 12) and the financial data has not been kept separate for each type. The number of ARGOS orchards which financial data was available for each year on average, for the 2002/03 to 2008/09 period, was 7 for Green, 11 for Green Organic and 8 for Gold. Data for only five of the Gold orchards was included in the analyses presented here as the others did not have separate Gold data.

6.3 Financial indicators

Gold orchards had significantly higher gross orchard revenue (GOR), orchard gate return (OGR) and cash operating expenditure (COE) than Green and Green Organic orchards (Figure 24). However, there was insufficient statistical power to any detect any differences between the Green and Green Organic panels for these variables.

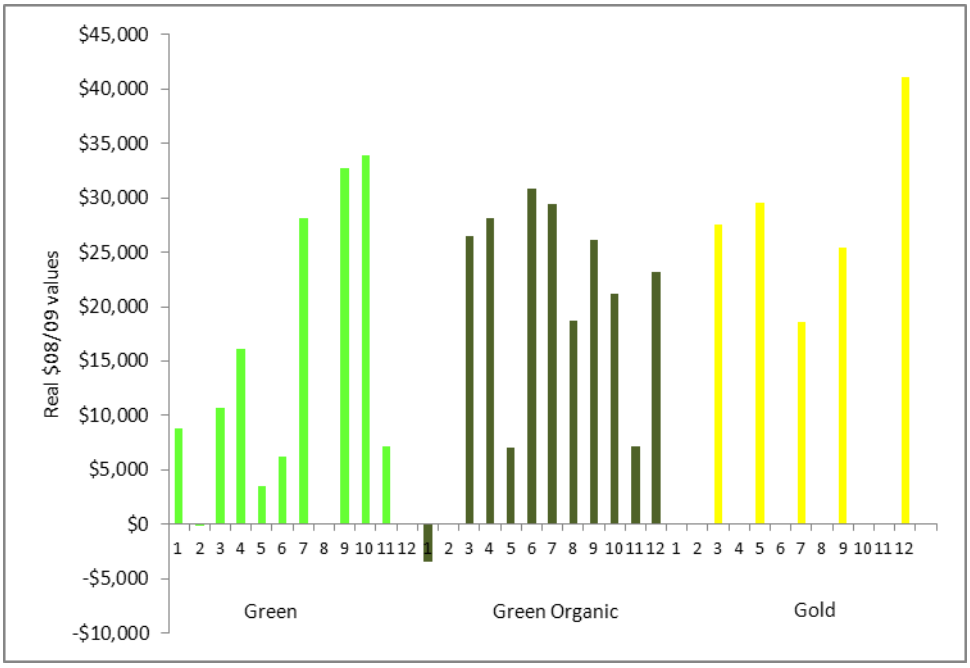
Considerable variation between orchards for Cash Orchard Surplus (COS) (Figure 25) and low sample size meant we did not have enough statistical power to ascertain if there were any significant differences for this bottom-line variable.

Figure 24. Average values of key financial aggregates for ARGOS kiwifruit orchards over seven years (Real $2008/09 values)*.



* Data here is for only five of the 12 Gold orchards. Data was analysed in Genstat using REML procedure with System*Season as the Fixed Model and Cluster/Property as the Random Model. For each aggregate, bars with the same letters above them are not significantly different.

Figure 25. Average Cash Orchard Surplus (COS) per hectare for ARGOS kiwifruit orchards over seven years (Real $2008/09 values)*.

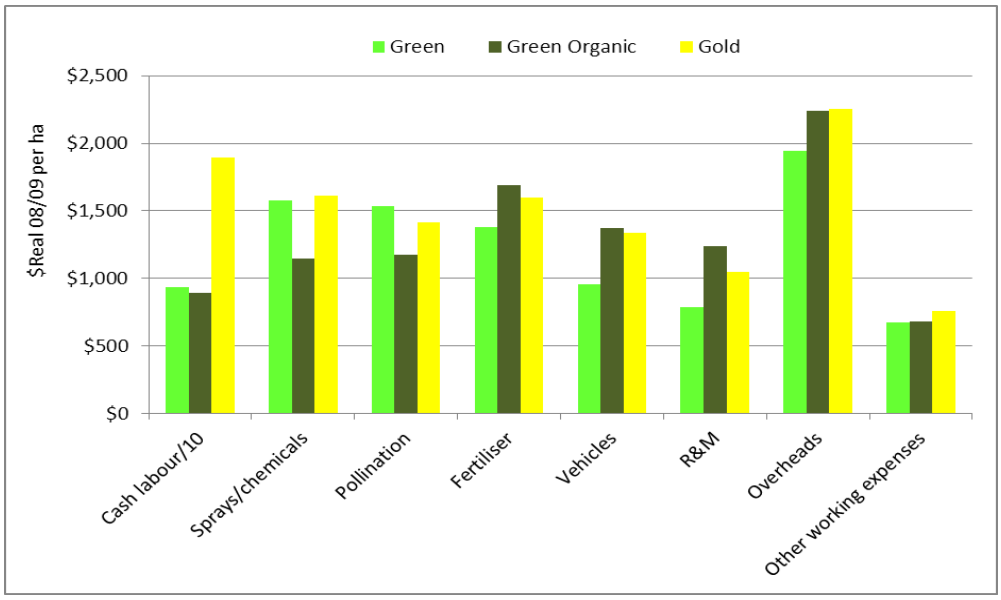


* Data here is for only five of the 12 Gold orchards. Each vertical bar represents an individual orchard. The absence of a bar means data was not available for that particular orchard.

6.4 Individual cost categories

Average values for individual cost categories for the 2002/03 to 2008/09 period are shown in Figure 26. Of these, only cash labour differed significantly between panels with Gold being significantly higher than the other two. No other significant differences were detected. Low statistical power may have disguised any significant differences which may have existed.

Figure 26. Average values of individual cost categories for ARGOS kiwifruit orchards over seven years (Real $2008/09 values). Statistically significant differences were only detected for cash labour with Gold > Green & Green Organic*.



* Data here is for only five of the 12 Gold orchards. Data was analysed in Genstat using REML procedure with System*Season as the Fixed Model and Cluster/Property as the Random Model.

6.5 Financial summary

Overall orchard revenue and expenditure has been found to be highest for Gold orchards. However, due to the considerable variation between orchards, and our small sample size, we did not have enough statistical power to conclude if there were any differences or not in other financial variables between ARGOS panels including cash orchard surplus. This work highlights the difficulty in getting a sufficient amount of good comparable financial data for orchards.

7. Capital based sustainability indicators as a possible way for measuring agricultural sustainability

7.1 Introduction

The following is modified from a recent ARGOS report (Saunders et al. 2010). It explores the application of a capital based approach to sustainability in agriculture. This approach argues that for future generations to be as well off as the present then the capital base approach should at least be maintained. The main types of capital explored by ARGOS are as follows:

- Human capital includes knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being. It is created through lifelong experience as well as formal education.
- Social capital has been defined as the 'network of shared norms, values and understanding that facilitate co-operation within and between groups'.
- Human-made capital refers to public and private capital such as buildings, factories, office blocks, plant and machinery, computers, infrastructure, airports, seaports, highways, roads, railways, schools and hospitals.
- Natural, or environmental, capital in economics is generally classified into three types: extractive resources such as soil, minerals, forests, fish and water; amenity values (direct and indirect) such as landscapes, native bush, recreational fishing; and assimilative capacity or the ability of the environment to 'process' waste pollution. Natural capital is different from the other types of capital discussed above because of the irreversibility of some forms of natural capital when used.

While there is likely to be varying views about what is required within the various components in ensuring sustainability within a given situation, when it concerns agriculture, in all cases there is a strong dependence on the availability of a range of different types of resources.

7.2 Human-made capital

There was a significant difference between kiwifruit systems grown for both measure identified for human-made capital for kiwifruit orchards (Table 7). With respect to Land & Buildings, the quotable value (QV) of Gold orchards was significantly higher than that of Green and Green Organic orchards. In relation to plant, machinery & vehicles, a clear significant difference between systems was observed. Green orchards had plant, machinery and vehicles that were worth significantly more than Green Organic and Gold orchards. There was no significant difference between the debt: equity ratio for kiwifruit orchards.

Table 7. Means and significant differences between Green, Organic and Gold kiwifruit orchards for selected human-made capital measures (for the 2002/03 to 2007/08 period).

	Land & Buildings	Plant, Machinery & Vehicles	Debt: Equity Ratio
Green	$353,000 a	$39,000 a	0.15
Green Organic	$332,000 a	$14,000 b	0.14
Gold	$436,000 b	$8,000 b	0.11
Significant difference	*P<0.05*	*P<0.05*	*Not significant*

*An unbalanced ANOVA was used. Within each column, values with the same letter are not significantly different. Values rounded to the nearest thousand. Land & building values were obtained from Quotable Value NZ.

7.3 Social capital

No significant differences were found between systems for any of the social capital indicators (Table 8). However, what is more useful with measurements such as these are the changes over time that will have an impact on sustainability, rather than a one-off measurement (as there is no right or wrong level). Such measures should be constant, if not improving over time, and thus a simple one-off measurement such as this is not particularly useful at this early stage. Further research over time is required to see if the measures used in the present research are useful, and whether there are in fact changes over time, both at an orchard-type level and at a measurement level. Research is currently being undertaken to re-measure these indicators in upcoming years.

Table 8. Means and significant differences between Green, Organic and Gold kiwifruit orchards for selected social capital measures*. Responses were on a 7-point scale, with one representing 'not at all involved', and seven representing 'heavily involved'.

	Voting in National Elections	Voting in Local Elections	Providing Cash Financial Support to Community Activities	Orchard is Contributing to the Local Community
Green	5.9	5.5	3.7	4.7
Organic	5.8	5.3	3.3	5.6
Gold	5.6	5.0	3.2	4.6
Significant Difference	*Not significant*	*Not significant*	*Not significant*	*Not significant*

* Based on one year's data only. An unbalanced ANOVA was used.

7.4 Natural capital

ARGOS's evaluation of the natural environment in kiwifruit orchards has revealed a number of significant differences between production systems. This includes differences in soil quality and biodiversity (see earlier sections of this report for more detail).

7.5 Conclusion

Although ARGOS has found a number of significant differences for different measures of capital, there is no right or wrong level for many of these. What is more important is change over time. For most measures, remaining consistent or increasing over time is more important than the current level. For example, many of the social capital measures like voting participation should remain the same over time, if not increase. Having said that, there are some measures that need to remain constant or decrease, e.g., greenhouse emissions. Similarly, many of the natural capital measurements are likely to have an 'ideal' range at which they should fall between (to ensure that deterioration is not occurring to the natural environment). The ARGOS work to date provides a platform for further research of capital indicators in order to build a bigger picture of how these are changing over time.

8. Social

8.1 Introduction

The ARGOS social research team has used various quantitative and qualitative methods to examine the social dimensions of orchard and farm management (Table 9). The results from most of these have been presented in previous ARGOS reports.

Here we focus on an overview of the differences found between the three panels of orchardists being studied.

Table 9. Interviews and questionnaires which have been deployed by ARGOS's Social Objective.

Survey Name	Year	Interviewers
Qualitative Interview 1 Goals, vision, constraints, production issues	2004	Lesley Hunt
Qualitative Interview 2 Constraints/enablers	2005	Chris Rosin & Lesley Hunt
Causal Mapping 1 Understanding orchard systems	2005	John Fairweather
Causal Mapping 2 Understanding orchard systems and changes	2008	John Fairweather & Jayson Benge
National Farm Survey 1	2005	John Fairweather
National Farm Survey 2	2008	John Fairweather
Retrospective interview (including analysis of shocks)	2010	Chris Rosin & Lesley Hunt

8.2 Differentiation of green, green organic and gold orchardists

An analysis of all the social data collected by ARGOS to date (ex. 2010 retrospective interview data) has revealed the following differentiations between the three panels of orchardists i.e. Green, Green Organic ('Organic') and Gold. These are taken directly from Rosin et al. (2009).

"From the differences noted in the orchardists' subjectivities and attitudes, it is possible to designate two themes: breadth of view and good farming. The first theme involves the distinctions between the Organic and the other two panels - specifically their vision for the future and discussion of environmental and personal wellbeing in the first qualitative interview, the identification of intangible fruit qualities in both qualitative interviews and their reported participation in COKA from the survey. We argue that in each of these aspects, the Organic orchardists express greater awareness of and devote greater consideration to broader scale landscape and societal factors in developing their management systems. As such, the Organic orchardists may be more likely to adopt alternative practices on the basis of their environmental or societal benefits. The theme of good farming is more common in the existing social science literature and refers to an individual's concept of acceptable practice and their justification of these practices. In this case, it is possible to identify distinguishing characteristics of good farming among the panels. The concept of good

farming held by the Organic panel is distinguished by similar factors to that noted in their breadth of view. In addition, they are less committed to maintaining a tidy orchard, preferring to encourage biodiversity by means of more animal-friendly sward and shelterbelt environments. For the Green orchardists, by comparison, the tidiness of the orchard is a principal indicator of good farming as is production comparable to their peers and the presence of a numerous and diverse array of bird species. Environmental criteria are less evident in the representation of good farming found in the data from the Gold panel. For the latter group, the demonstration of innovative practice in pruning, shelter management and vine support structures is a more important indicator of good management. The expected reward for these efforts is increasing dry matter levels and production from their orchard, both of which are rewarded with incentives from ZESPRI.

The differences among the kiwifruit panels in relation to breadth of view and good farming suggest that members of the panels hold diverse palettes of acceptable practices. The Green orchardists, for example, appear to maintain a more restricted set of management options, relying on established guidelines and not as actively pursuing innovation. Generally, they consider alternative practices as viable only once these have been proven in trials and are recommended by either ZESPRI or their packhouse. The Gold orchardists expand their options through their pursuit of innovation with the goal of improving the productivity of the gold vines. This pursuit is, however, limited by its tendency to focus on orchard oriented objectives such as the productivity of the vines and the efficiency of shelterbelts. The Organic orchardists exhibit perhaps the greatest range of options, actively pursuing innovations to improve the organic product while referring to broader social and environmental implications of their practice. The Organic orchardists, however, also recognise the most restrictive audit criteria which exclude a suite of practices based on chemical treatments. The underlying tenets of resilience as a means to pursue sustainability assert that resilience is enhanced through access to a wider array of options. Thus, for the kiwifruit sector, the social data provide some evidence to suggest that the panels could be ordered from least to most resilient: Green, Gold, Organic. This statement does not, however, necessarily apply in reference to all potential shocks to kiwifruit production, some of which likely advantage a more conservative approach to innovation or change in practice.

Another avenue of notable means of differentiation among the kiwifruit panels involves their respective interactions with the environment. The assessment of this avenue refers to groups of responses relevant to the orchardists' positioning in regard to the environment, the environmental feedbacks to which they respond and the resultant features of their management systems. From the perspective of environmental positioning, the Organic panel consistently demonstrated a greater level of interaction with environmental features, being more proactive in their engagement with the environment, seeking to create a haven for diverse life forms on the orchard and stating greater awareness of their position as part of natural systems. It is more difficult to differentiate between the Green and Gold panels from this perspective, although the former is more passive and the latter more active in their engagement with the environment. The relative environmental positioning of the three kiwifruit panels reflects arguments referring to breadth of view above. In this case, members of the Organic panel are expected to place greater weight (in comparison to the other orchardists) on environmental relative to economic justifications of acceptable practice—thereby increasing the likelihood of environmentally sustainable management. Such a predisposition does not, however, necessarily lead to measurable differences in environmental impact.

Further differentiation may be made between the panels with reference to the feedbacks to which they respond in their management systems. These feedbacks include a range of indicators to which the orchardists refer in assessing the current state of their properties. For example, the 'look' of the orchard signifies the wellbeing of its environmental, economic and social states. For the Green panel a tidier orchard (referring to all of its elements: vines,

structures, sward, shelter, buildings, etc.) provides evidence of the owner's attention to detail and capacity to control external impacts on production. For these orchardists, the association between the pursuit of a tidy orchard and good farming is reinforced by the perception that their management contributes to an increasing number of birds that inhabit their orchards. The appearance of the orchard appears to be a stronger signifier of a healthy management system than its production, which is of secondary importance as long as targeted returns are achieved. By comparison, the Gold panel are more likely to refer to indicators that are more directly related to production: attention is more narrowly focused on the vines (pruning to combat the vigour of the vine, which contributes to fruit size and dry matter); achieving better production statistics than colleagues is an important endeavour; and biodiversity does not appear to enter assessments of management, except where birds are identified as pests that damage buds on the vines. Finally, the Organic panel respond to a unique set of feedbacks that privilege indicators of biodiversity—as is evident in a busy orchard (less tidy; more noisy; healthy smell)—over those of production (production indicators are only important in establishing competitive potential of organic relative to more conventional management practices). These panel differences identify the relative attention that orchardists pay to diverse features of their production systems. The relevance of such differences for sustainable agriculture will become apparent to the extent that the distinctive feedbacks help to explain any economic or environmental differences between the panels.

Due in part to their varying attention to system features and feedbacks, orchardists in each of the panels identify and respond to distinct sets of incentives when developing their farm (orchard) management approaches. In this case we suggest that, despite the basic shared practices of orchard management, individual orchardists will strategically employ practices that conform to their management objectives. Thus this theme incorporates such differences as: a) the greater reliance on family and casual labour and the cooperative development of knowledge and skills among the Organic orchardists; b) the greater production orientation, the propensity to live on the orchard and reliance on proven practices among Green orchardists; and c) the stronger business orientation, greater involvement of managed orchards and tendency towards self-driven innovation in vine management among the Gold orchardists. The differences between the panels indicate several areas of greater or weaker flexibility of management, including dependence on positive labour relations, potential creativity in responding to system shocks and the capacity to incorporate environmental concerns within management decisions. As a whole, such management differences also define a distinct, but difficult to elaborate, scope of control realised by each panel: a) the Green orchardists appear to assume that the kiwifruit orchard is subject to almost absolute control (there is or should be a management solution for any problem, preferably devised by the packhouse or ZESPRI); b) the Gold orchardists demonstrate a perception that, by creatively controlling the gold vines, they can achieve desired ends—thus, the importance of having the orchards show signs of their innovativeness; and c) the Organic orchardists engage in a controlled proliferation of biodiversity that is capable of enduring wilder actions by the 'accepted' elements of the system. The relevance of these distinctive panel characteristics to the sustainability or resilience of orchard management will likely depend on the specific pressures the sector faces at any particular time. All involve strategies designed to deal to aspects of orchard management that are considered a particular challenge of the system employed. Thus, based on the persistence of each panel, they demonstrate some level of resilience to changing regulatory, economic and environmental conditions. Similarly, however, it is possible to identify potential elements of brittleness in each: the apparent inflexibility of proven practice, including a reliance on hydrogen cyanamide; the limitations on management options posed by organic certification criteria; or the risks of innovation in managing at the edge of production and quality. Furthermore, members of all of the panels demonstrated a desire to exert control over their orchards, albeit with some relative laxity amongst the organic orchardists.

The final avenue of variation among the kiwifruit panels consists of their interactions with a wider society. Here we refer to differences in the on and off-farm relationships of the orchardists, including the orchardists' responses to innovation and risk. Again, in their relationships with society, the Organic panel differs somewhat from the other panels taking both a broader view of community (noted above) and perceiving themselves as providing a beneficial environment for their neighbours while emphasising the importance of family life within the orchard experience. On the other hand, they tend more toward self-reliance with higher levels of owner and family labour in the management system. The greatest contrast to the Organic panel from this perspective appears to be the Gold panel which includes more managed properties, relies more heavily on contracted and permanent labour and has a stronger business orientation. The differences between the Organic and Gold panels (as well as those noted in the feedbacks above) do not result in strong panel effects in regard to the orchardists' approaches to innovation and risk taking. In this regard, it is the Green panel that demonstrates a distinctively low level of innovativeness. Overall, these differences suggest that members of the Organic panel are more likely to take account of social issues or concerns in their management approaches. As a result of this characteristic, the Organic orchardists may be more resilient in the face of demands for more stringent social or environmental criteria driven by consumers in export markets. The differences in social dimensions identified among the kiwifruit panels fail to identify any of the management systems as optimal to the exclusion of the others. A more accurate assessment suggests that the interactions among the different management systems may better explain the current resilience of the sector. The differences between panels provide evidence that there is a wide diversity of 'acceptable' practices which contribute to the overall goal of producing fruit that meets the standards required for an international market. The management systems associated with each panel enable the orchardists to achieve additional objectives (e.g., environmental benefits, greater certainty of production, challenge and opportunity to innovate) which make them more attractive to individual orchardists. The current strength of the sector suggests that kiwifruit orcharding is accessible to a wide range of 'identities' as people entering it are likely to come from diverse backgrounds and therefore institute into their practices innovation derived from their earlier enterprises. In addition, there is evidence of significant levels of redundancy in the sector expressed in the acceptance of the apportioning of payouts (as mediated by ZESPRI) and the willingness and capacity to learn from the experiences of orchardists engaging in other management systems."

9. An analysis of drivers for environmental sustainability in the New Zealand Kiwifruit Industry, performance and possible responses

The following text is taken directly from a report delivered to ZESPRI in 2010 by ARGOS (Benge et al. 2010).

"**1. Report Scope**
This report has been prepared to assist the kiwifruit industry understand the issues, risks and opportunities in relation to environmental sustainability. It provides the following:

1. Trends and the possible future business, market and regulatory requirements and responses around environmental issues.
2. Options for monitoring the environmental impacts of production including an assessment of the applicability of established agricultural environmental indicators (AEIs).
3. An outline of the known environmental impacts of kiwifruit production.
4. An analysis of the receptiveness of the Industry, particularly growers, to sustainability initiatives that demonstrate to markets greater environmental stewardship.
5. Recommended approaches that could enhance the environmental outcomes of orcharding and/or which will add value to New Zealand kiwifruit.

2. Drivers for Sustainability
In relation to the New Zealand kiwifruit industry a number of drivers for enhancing the sustainability of individual producers as well as the whole industry are reviewed. These include:

- Business management and resource use optimisation
  - Business improvement - evidence is provided to support that a sustainability focus can enhance business performance, encourage innovation, identify and manage risks, improve stakeholder relationships and enhance the overall resilience of a business to manage changing circumstances and crisis. This focus is becoming mainstream with expectations coming from key value chain operators for a commitment to sustainability from others involved in value chains.
  - Resource use optimisation - opportunities for environmental as well as economic gains through the optimal use of resources are outlined.
  - Ecosystem services - the concept and the potential for new revenue streams from providing and enhancing environmental resources is presented. These could create new incentives for good environmental stewardship.

- Market demands

Trends in consumer and market demands for information on the environmental impact of food production are outlined. These are significant and widely held (even though the evidence for the pro-environment benefits of these is weak and somewhat contradictory). They are reflected in the following:

  - Significant growth in the Lifestyle of Health and Sustainability (LOHAS) and organic markets.
  - Increased support for local food consumption - reflected in the `buy in season', `buy local', food miles and alternative food network initiatives.
  - Emerging concerns around environmental issues like climate change, carbon and water footprints, production impacts on biodiversity, and waste.

- Regulatory drivers
    - A review of trends in relation to the management of New Zealand environmental regulations indicates increasing regulatory oversight and emerging controls for mitigation of the environmental impacts of farm production. The potential impact of this new regulatory activism and other environmental regulations (biosecurity, pesticide registration and biodiversity protection) on the kiwifruit industry is explored.
    - International trends in environmental regulations and their potential impact on trade are also reviewed. Establishment of many new policies and regulations to decrease emissions have resulted from climate change concerns. Though international trade rules (WTO) state that environmental regulations are not to be used as unnecessary barriers to trade, a greater potential impact on trade is identified from market customers (such as retailers) who are outside the coverage of the WTO and other trade regulations.

- Other drivers
    - Public perceptions - these are closely linked with and influence both market and regulatory drivers. Unfortunately, because NZ is promoted as 'Clean & Green' it leaves itself open to attack from competitors. It must therefore be prepared to respond to any negative perceptions.
    - The role of non-government organisations (NGOs) - these can have a significant impact on societal values and influence the operating environment for farming in the long term. Issues like 'water quality protection', 'water conservation' and 'biodiversity protection' are common with at least four of the NGOs and are therefore more likely to be scrutinised in the future compared to other environmental concerns.

3. Analysis of Drivers

An analysis of the importance of environmental drivers in relation to the New Zealand kiwifruit industry was used to identify and rank the potential threats and opportunities for the industry as a whole.

Significant opportunities are:

- Business improvement gains from an enhanced focus on sustainability
- Markets developing for ecosystem services
- Gains from improved efficiency in resource use

Significant threats are:

- Establishment of new pests
- Climate change
- Loss or degradation of ecosystem services
- Regulatory controls on production inputs e.g. HiCane

4. Environmental Impacts of Production

The research to date, particularly the Agriculture Research Group On Sustainability (ARGOS) programme, has shown that kiwifruit production in NZ has a generally favourable environmental footprint. At the local orchard scale, important factors like soil quality and terrestrial biodiversity (e.g. bird abundance) are favourable compared to other farming systems and habitats although there are some areas where there may be an opportunity for gains e.g. encouragement of native bird species. Recent changes in the crop protection programme for kiwifruit, in terms of the sprays used and best practice, have further lowered the associated environmental risks. Also, there is no evidence that threatened species are an issue for kiwifruit production (although the invertebrate community which is likely to be very large and contain native species has not been fully studied). At a broader scale, the evidence available indicates that the environmental impacts of kiwifruit production are small

as highlighted by a recent study of sedimentation levels in the local harbour. Compared to other agricultural sectors which rely on animals the ecological footprint of kiwifruit production is likely to be much smaller and initiatives are well underway to improve in this area including the recycling of waste.

5. Sustainability Monitoring and Reporting

Environmental

An overview of approaches to environmental monitoring and reporting is provided as well as an analysis of frameworks for understanding and responding to environmental issues. International monitoring and reporting frameworks are likely to be unsuitable for assessing the environmental trends specifically for NZ's kiwifruit industry. Similarly, national programmes are unlikely to be appropriate although they could provide insights into the type and scope of indicators to monitor and report on. Local councils undertake a range of environmental monitoring and reporting and where possible any specific work in the kiwifruit industry should be aligned with this.

Corporate

An overview of sustainability reporting initiatives is presented. This includes a discussion of those which have emerged to help businesses advise community and other stakeholders about environmental performance. Tools which have been developed to help NZ businesses gauge their environmental performances (e.g. EnvironStep) are discussed - the conclusion about these is that in their current form they are too generic for NZ farming businesses.

6. Frameworks for Responding to Environmental Issues

A number of frameworks have been established to guide the assessment of environmental and agriculture interactions. Some of these may provide the kiwifruit industry and its stakeholders with a different perspective and understanding that could enhance the industries responsiveness to environmental issues and risks and opportunities that may emerge from these. A number of frameworks are discussed (e.g. Social-ecological Resilience Theory, Capitals Approach, Pressure-State-Response, Life-cycle Assessment, and Environmental Management Systems) along with identification of the most relevant ones for the kiwifruit industry.

7. Responsiveness of Growers

ARGOS surveys have demonstrated that growers' priorities are very much production and profitability. Growers' saw broader environmental indicators (e.g. biodiversity, number of birds) as slightly important at best. Strategies/initiatives which set out to lift the level of environmental qualities of orchards would need to be considered carefully before implementation as there is likely to be some resistance to them. There is however a number of opportunities for win: win situations where improved environmental performance can be achieved as well as improved production and financial performance. For example improved efficiency in resource use, enhanced natural capital (e.g. improved levels of biological control compared with the use of chemical inputs) and improved energy efficiency (which would decrease the reliance on fossil energy, decrease the carbon footprint and provide cost savings in production, packaging and transport).

This reports briefly describes tools and strategies that growers and Industry could use to help understand and respond to the impacts of production e.g. AgResearch's Overseer® Nutrient Budget Program which provides an evaluation of environmental impacts.

8. Recommendations for Advancing the Sustainability of the New Zealand Kiwifruit Industry

The following recommendations are suggested to enhance the sustainability of the New Zealand kiwifruit industry:

A. Increase Strategic Focus

There are a number of reasons for the kiwifruit industry to understand and adopt sustainability as a key focus for industry development including opportunities for business improvement, and market and regulatory factors. The current proactive industry approach to anticipating sustainability issues and developing appropriate responses is more advanced than most sectors and is encouraged. The ZESPRI sustainability focus area could be strengthened through an increased emphasis on sustainability and resilience in the company's strategic and operational plans and decisions.

B. Increase Responsiveness to Complex Market Signals

A more cohesive strategic response may be required to respond to the multitude of emerging issues regarding the environmental integrity of kiwifruit production. An expansion in the range of environmental and other indicators monitored to assist in addressing environmental, regulatory and business improvement drivers is recommended. These include:

- Enhancing market responsiveness - biodiversity impacts and trends; environmental footprints e.g. carbon, water, energy, waste.
- Regulatory responsiveness - an understanding of regional council environmental monitoring programmes and the proactive analysis of kiwifruit performance in relation to those programmes.
- Business improvement - objective corporate reporting of environmental and social performance.
- The following frameworks are recommended as options for guiding the kiwifruit industry's understanding and response to environmental issues:
- Capitals approach - for monitoring and interpreting a broad range of indicators of sustainability.
- Environmental management systems - to enhance responsiveness to market demands for assurance of the environmental and other impacts of production. This approach could be used to incorporate an increased emphasis on orchard and environmental planning into existing assurance programmes.
- Triple bottom line reporting - to enhance the quality of reporting on New Zealand kiwifruit production and impacts for public and business accountability, the establishment of a robust triple bottom line reporting process that aligns with international standards such as Global Reporting Initiative (GRI) is recommended.
- Social-ecological resilience theory - for understanding and guiding the kiwifruit industry through complex global turbulence (environmental, social, economic) and enhancing the industry's ability to transform to respond to these.

C. Grow Organics – A Possible Flagship and Resource for the Industry?

Although kiwifruit orchard environments are on the whole good, there is evidence that organic orchards are better environmentally (while the differences are small they are statistically different). A lift in the proportion of organic orchards and/or a greater use of practices more common on organic orchards (e.g. compost applications) across the industry would therefore be expected to enhance the overall environmental footprint of the kiwifruit industry. There are likely to be economic implications associated with an increase in organics (e.g. erosion of organic premiums) so a full understanding of these would be required to assess the impacts of such a change. It should be noted that there are opportunities for enhancement of many organic systems and their environmental performance with a shift to also considering actively managing biodiversity and ecosystem services as well as the current primary focus on the restriction of inputs.

D. Maintain or Enhance Investment in Sustainability Research

It is recommended that there is on-going industry investment in an independent and systematic on-orchard environmental monitoring programme to establish trends and confirm whether things are improving, staying the same of deteriorating (the ARGOS research programme has been working in this space for a number of years now and would be able to provide considerable guidance). Support of an initiative like this would demonstrate a commitment to customers and any positive findings could be used to strengthen the ZESPRI/New Zealand kiwifruit brand (negative findings could be used to help steer the Industry in the right direction).

Priority areas for monitoring should include: soil quality, terrestrial biodiversity, water use and quality and energy. In addition the following research areas are recommended:

- Development of ecological subsidy budgets (this would be useful for demonstrating the value of ecosystem services).
- Kiwifruit nutrition - this could lead to gains in fertiliser use efficiency, minimise environmental impacts and reduce growing costs.
- Waste stream research - further quantification of the waste stream and identification of strategies for minimisation of waste through the kiwifruit supply chain as well as optimising its use.

E. Attain and Communicate Clear Signals for Greater Grower and Industry Support

Growers are unlikely to welcome any environmental initiatives particularly those that will add cost to their business. Clear market signals and benefits or lost opportunities will need to be identified and communicated effectively before environmental initiatives are voluntarily accepted.

F. Establish Collective Responses

There are some market perception threats that are better addressed through a New Zealand Inc. approach than just by the kiwifruit industry due to the general perception of New Zealand, its environment and products. The MFAT Sustainability Foods Export Group provides one forum for the development of co-ordinated New Zealand responses and ZESPRI is well placed to support this group and other industries to anticipate and proactively respond to potential negative issues - as well as highlight positive aspects of New Zealand`s environmental performance.

G. Maintain or Strengthen Community Relationships

The maintenance of good relationships with local communities by individual growers and the industry will be important for maintaining the `licence' to operate and minimise additional costs that could be imposed on kiwifruit production if restrictions were put in place. The New Zealand kiwifruit industry has a good story in relation to its environmental impact and this needs to be communicated to the wider New Zealand public so as to sustain goodwill and support. The following are examples of positive industry features that could be highlighted:

- Kiwifruit is a fruiting plant and not grown particularly intensively with a positive level of energy efficiency e.g. 2-4 times the energy output from what is put in.
- Kiwifruit is not threatening large tracks of indigenous habitat or any native flora or fauna.
- Kiwifruit production can have a positive impact on biodiversity as well as provide other ecosystem services e.g. sequester carbon.
- Kiwifruit production generally does not negatively impact on water, soil or air quality."

10. Summary

The ARGOS research programme, “Pathways to Sustainability in Primary Production”, commenced in 2003 with the goal of evaluating the sustainability and socio-ecological resilience of farming in NZ. The basis of this work is the characterisation of the management, environmental, economic and social features of different farming systems. This report focuses on the most recent findings for the Kiwifruit sector where the three main production systems are being studied. Previous reports like this one have presented earlier findings. Generally, the Green Organic kiwifruit system has emerged as the most different with the differences between Green and Gold being fewer or less pronounced. Below is a list of the significant differences presented in this report:

- Production - number of trays/ ha, fruit size and dry matter content (TZG)
- Management - number who use supplementary pollination, number of sprays applied, amounts of macronutrients applied to soil, number of times orchard floor mowed and mulched, percentage of orchards aiming for replacement cane or a mixture of wood.
- Environment - many soil attributes, relative abundance of native bird species and cicadas
- Financial - cash labour, total revenue and expenditure indicators
- Capital - human-made (land & buildings, plant & machinery), financial and natural capital
- Social - orchardists’ view of what good farming entails, breadth of view, feedbacks management approaches, on- and off-farm relationships.

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1. Background to the ARGOS Programme
2. Transdisciplinary Research
3. Cicadas in Kiwifruit Orchards
4. Market Developments for NZ Agricultural Produce
5. Spiders in Kiwifruit orchards
6. Organic Kiwifruit Survey 2003
7. Analysis of ZESPRI's Organic Kiwifruit Databases
8. Types of Kiwifruit Orchardist

9. First Kiwifruit Interview: Individual and Orchard Vision
10. Sketch Map Results: Kiwifruit Sector
11. Sketch Map Results: Sheep/Beef Sector
12. Positive aspects of wellbeing for ARGOS sheep & beef farmers
13. What makes ARGOS sheep & beef farmers stressed?
14. Ways in which ARGOS sheep & beef farmers managed the stress of farming
15. Soil nematodes in kiwifruit orchards
16. Understanding kiwifruit management using causal maps
17. Bird Sampling Methods
18. Birds on sheep/beef farms
19. Birds on kiwifruit orchards
20. Management of Data in ARGOS
21. Evaluation of the bait-lamina test for assessing biological activity in soils on kiwifruit orchards
22. Annual monitoring of cicadas and spiders to indicate kiwifruit orchard health
23. Cicada Species in Kiwifruit Orchards
24. Shelterbelts in kiwifruit orchards
25. Biodiversity on Kiwifruit Orchards: the Importance of shelterbelts
26. Kiwifruit orchard floor vegetation
27. Monitoring stream health on farms
28. Stream management: it really matters what you do on your own farm!
29. Soil Phosphorus and Sulphur levels in Dairy farms
30. Soil Phosphorus and Sulphur levels in Sheep & Beef farms
31. Assessing the sustainability of kiwifruit production: the ARGOS study design
32. Fertiliser use on ARGOS kiwifruit orchards
33. How ARGOS uses Geographical Information Systems (GIS)
34. Food Miles
35. Understanding sheep/beef management using causal maps
36. Earthworms in kiwifruit orchards
37. Four types of sheep/beef farmers across the ARGOS panels
38. Audits and Sheep/Beef Farm Management
39. Quality Assurance Programmes in Kiwifruit Production
40. High Country Woody Weeds
41. The Relevance of Performance Indicators Used for Non-Agribusinesses to Kiwifruit Orchards
42. The Relevance of Performance Indicators Used for Non-Agribusinesses to Sheep and Beef Farms
43. Common elements of pastoral farming systems as shown by causal mapping
44. Differences in soil quality within kiwifruit orchards
45. Differences in soil quality between organic and conventional kiwifruit orchards
46. Strong production focus shown in kiwifruit causal mapping
47. Relative abundance of cicadas in ARGOS kiwifruit orchards: 2010 update

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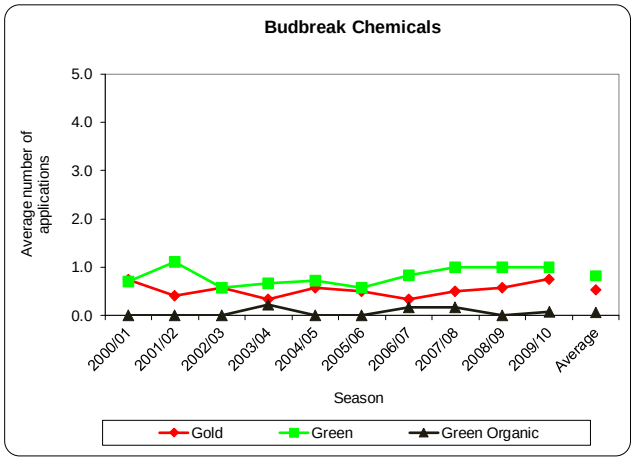
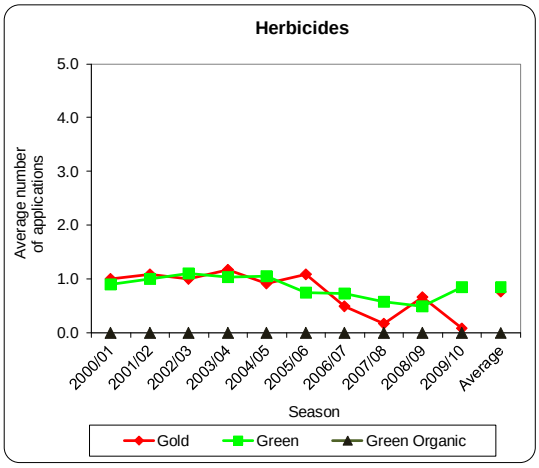
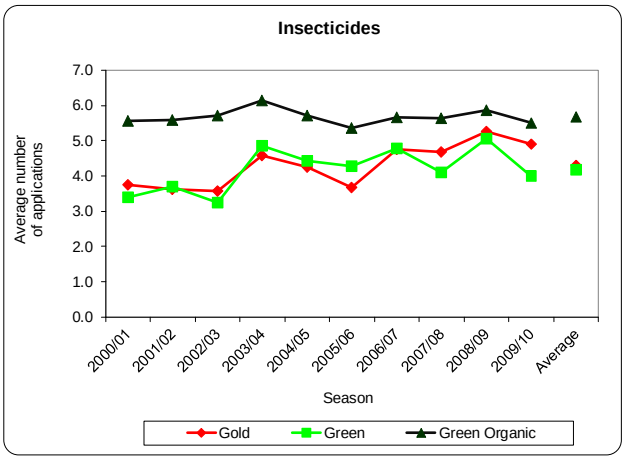
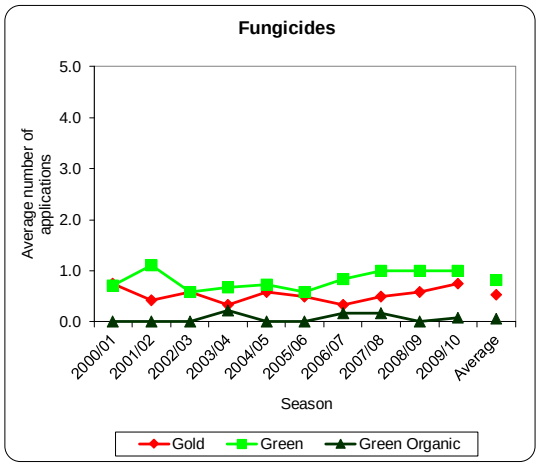
Appendices

Appendix 1. Trends in the average number of sprays applied to orchards in the ARGOS programme. *All sprays applied to organic orchards are certified organic and have lower potential toxicity.*



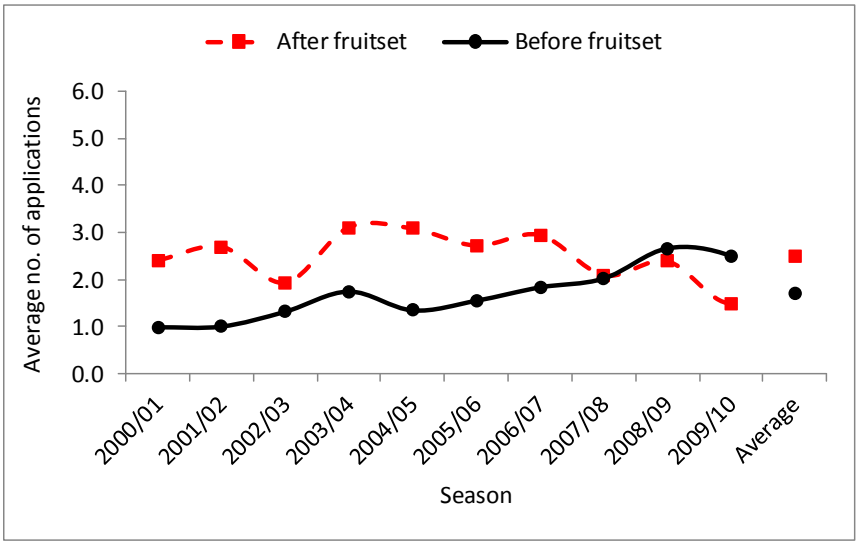




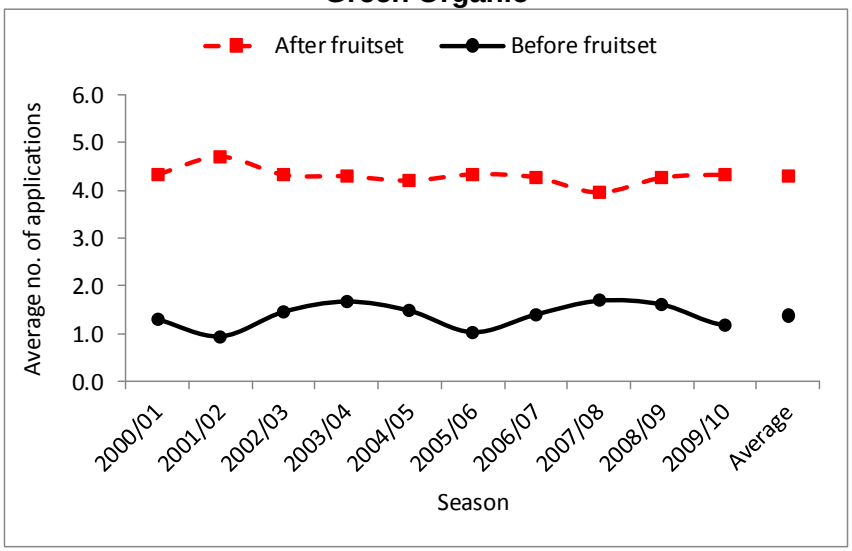


Appendix 2. Trends in total insecticide use on ARGOS orchards pre- and post-flowering. Based on data obtained directly from spray diaries held by ZESPRI.

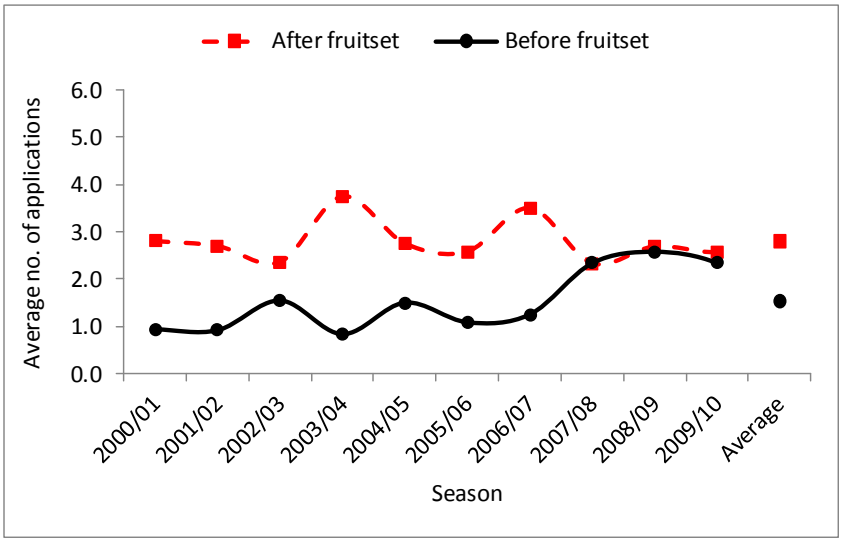
Green



Green Organic



Gold



Appendix 3. Significant differences in soil chemistry between ARGOS production systems and sample areas within blocks*.

Greater/less than signs indicate the direction of difference. Letters together within a bracket are not significantly different. NS = no significant differences. 5% significance level used.

A = Green, B = Green Organic, C = Gold.

	Year		
	2004	**2006**	**2009/10**
No. of clusters sampled	*All 12*	*All 12*	*All 12*
pH	C < A < B	C < A < B	C < A < B
P retention	A < (B,C)	A < B	Not measured
Olsen-P*	B < (A,C)	B < A < C	B < A < C
Resin-P*	Not measured	(A,B) < C	Not measured
Total BS	C < A < B	C < A < B	C < A < B
CEC	(A,C) < B	A < (C,B)	A < C < B
Available nitrogen*	(A,C) < B	A < C < B	A < C < B
Total C	A < (B,C)	A < C < B	A < (C,B)
Total N	A < C	A < (B,C)	A < C < B
C:N ratio	C < B	C < (A,B)	ns
Calcium	C < A < B	(A,C) < B	A < C < B
Magnesium	(A,C) < B	A < C < B	A < C < B
Potassium	NS	A < C < B	A < B
Organic S	Not measured	A < B < C	Not measured
Sulphate-S*	B < (A,C)	B < A < C	Not measured

BR = between-row (alleyways), WR = within-rows (under the leaders).

	Year		
	2004	**2006**	**2009/10**
No. of clusters sampled	*All 12*	*All 12*	*All 12*
pH	NS	NS	BR > WR
P retention	NS	NS	Not measured
Olsen-P*	BR < WR	BR < WR	BR < WR
Resin-P*	Not measured	BR < WR	Not measured
Total BS	NS	BR > WR	BR > WR
CEC	NS	BR > WR	BR > WR
Available nitrogen*	BR > WR	BR > WR	BR > WR
Total C	BR > WR	BR > WR	BR > WR
Total N	BR > WR	BR > WR	BR > WR
C:N ratio	NS	BR < WR	NS
Calcium	BR > WR	BR > WR	BR > WR
Magnesium	NS	NS	NS
Potassium	NS	BR > WR	BR > WR
Organic S	Not measured	NS	Not measured
Sulphate-S*	NS	BR < WR	Not measured

*Data analysed by ANOVA with cluster/block as the block structure and production system x landform as the treatment structure. Duncan's multiple comparison tests used to identify differences. *Variable log-transformed prior to analysis.