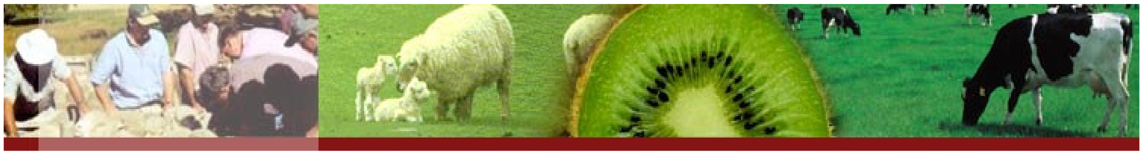
ARGOS

AGRICULTURE RESEARCH GROUP ON SUSTAINABILITY



A1 6.10 Stakeholder Report: September 2005

ARGOS Annual Kiwifruit Sector Report

Compiled by Jayson Benge, ARGOS

The AgriBusiness Group™

Lincoln University
Te Whare Wānaka o Aoraki

University of Otago
Sapere Aude
Te Whare Wānanga o Otāgo

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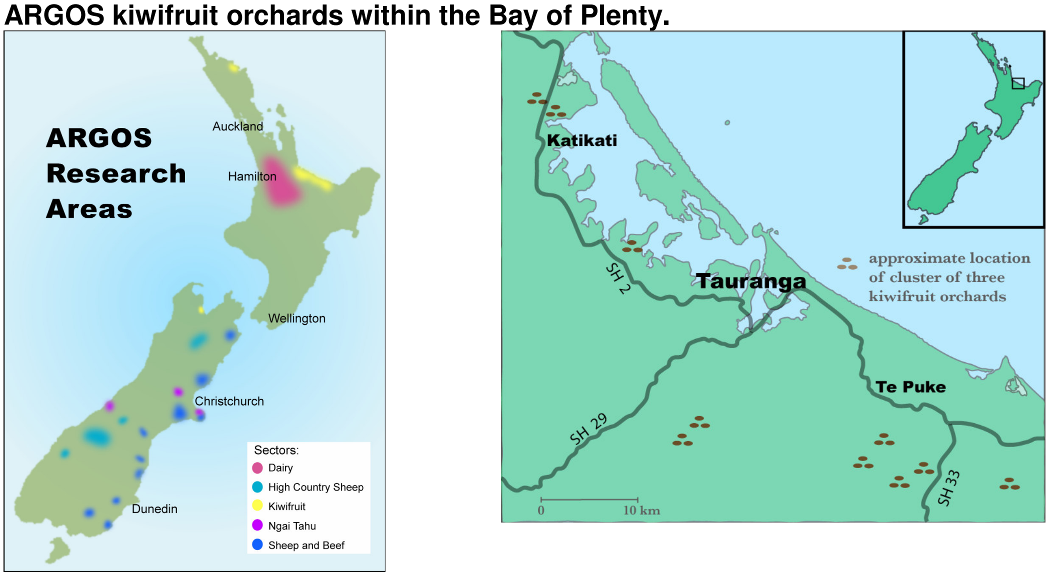
1.0 Introduction

ARGOS is an unincorporated joint venture between Lincoln University, The University of Otago and The Agribusiness Development Group Ltd. The research being undertaken by ARGOS is funded by the Foundation for Research and Technology (FRST), and industry partners. ARGOS is undertaking a scientific longitudinal study to investigate the environmental, social and economic consequences of different farming systems in a number of sectors including kiwifruit, sheep & beef, high country, dairy and Ngai Tahu Land Holdings. The null hypothesis, for this study, is that there are no environmental, social and economic differences between management systems. The management systems for participating kiwifruit orchards in ARGOS are:

i. KiwiGreen Hayward
ii. Organic Hayward
iii. KiwiGreen Hort16A

The orchards have been partitioned into 12 clusters (a group in close geographic proximity) of three orchards per cluster. A cluster has one orchard of each management type. 10 of the kiwifruit clusters are located in the Bay of Plenty with one in Kerikeri and another in Motueka. The geographical spread of clusters in the Bay of Plenty is illustrated in Figure 1.

Figure 1. Coverage of ARGOS farms throughout NZ and the distribution of ARGOS kiwifruit orchards within the Bay of Plenty.



This report has been prepared to provide you with further information on the ARGOS project, as well as provide an update of some of the recent kiwifruit results. This report will be updated annually and will include information about the social, economic and ecological indicators being measured throughout the course of the research.

Please contact me if you have any queries.

Jayson Benge
07 572 7799
0272 580 770
jayson@agribusinessgroup.com
www.argos.org.nz

2.0 Orchard production

2.1 Introduction

The farm management component of the ARGOS programme acts as the link between the ARGOS farmers and the other research objectives by facilitating the collection of information via the Field Research Managers and contributing to its analysis. It also acts to investigate some topics that fall outside the primary scope of these other research objectives.

This section of the report provides comparative data for each of the production systems being studied. This information is designed to illustrate key production differences between ARGOS orchards and management systems. It is hoped that with time, we will be able to contribute to a better understanding of what might be contributing to differences in production particularly within panels (reasons for differences between management systems are reasonably well known e.g. use of Hi-Cane). Differences are likely to be a due to a combination in environmental, financial and social factors, all of which the ARGOS programme is attempting to provide some insight on (in a transdisciplinary approach).

Industry data presented here was obtained from ZESPRI databases and publications.

2.2 Recent production

Table 1 below presents recent production data (2004 and 2005) for each of the production systems under study. Production data was obtained from the ZESPRI submit database (and kindly provided by Glenda Williamson, ZESPRI). Dry matter data was obtained from ZESRPI's clearance database (and kindly provided by Alistair Mowat, ZESPRI). **Table 1 also presents the average dry matter results for Industry in 2004 and 2005 (Source: KiwiTech Seminar Handout- August 2005, p 4).**

As expected, in 2004 and 2005 ARGOS Hort16A orchards produced the most fruit per ha, the largest fruit and the highest dry matter results. Conversely, ARGOS Organic Hayward orchards produced the least fruit and the smallest fruit. In 2004, ARGOS Organic Hayward orchards had the lowest dry matter fruit but in 2005, the dry matter was similar to KiwiGreen Hayward.

So that better comparisons can be made between orchards, **2005 production results for individual ARGOS orchards in the Bay of Plenty are presented in Table 2** (data for the 3 ARGOS orchards in each of Motueka and Kerikeri has not been presented as it is possible for the participating orchardists in those regions to identify each others data). This table contains the average yield per hectare, the highest dry matter result, and altitudes for each orchard. For the Hort16A orchards, the first year of production (for Class I fruit) is also included as younger orchards tend to produce less fruit but with higher dry matter.

The intention is to update this production information each year with the most recent production data that is available so comparisons can continue to be made.

Table 1. Average production figures for ARGOS orchards and Industry.

Averages for ARGOS orchards

	2004 Averages			2005 Averages		
	KiwiGreen Hayward	Organic Hayward	KiwiGreen Hort16A	KiwiGreen Hayward	Organic Hayward	KiwiGreen Hort16A
Production area (canopy hectares) [a]	3.63	3.62	1.21	3.62	3.69	1.21
Average number of trays/ha (Class 1)	7444	5624	9153	7354	6013	8747
Average fruit size	34.53	36.99	30.04	33.83	36.37	31.92
Highest dry matter result	16.57	15.65	17.38	16.55	16.58	17.86

[a] Data provided by ZESPRI

[b] Count sizes 18 - 42 for Hayw ard and count sizes 16 - 39 for Hort16A

Industry Averages for Dry Matter %*

	2004	2005
KiwiGreen Hayward	16.3	16.27
Organic Hayward	15.62	16.23
KiwiGreen Hort16A	17.16	17.6
Organic Hort16A	18.39	18.83

* Averages of the highest results for each maturity area

Source: KiwiTech Seminar Handout - August 2005, page 4

Table 2. 2005 production data for individual ARGOS orchards in the Bay of Plenty.

2005 Results for Individual ARGOS Orchards

KiwiGreen Hayward

Orchard	Altitude	Growing structure	Full bloom date	Average yield (trays/ha)	Highest DM result (average DM%)	DM sample date
2	15	Pergola	22/11/2004	7002	16.61	14/05/2005
3	20	Pergola	30/11/2004	7967	16.51	03/05/2005
4	26	Pergola	25/11/2004	7367	16.81	18/05/2005
5	160	Pergola	11/12/2004	8965	16.25	03/06/2005
6	140	Pergola	9/12/2004	7340	15.68	08/06/2005
7	80	Pergola	25/11/2004	9872	16.35	13/05/2005
8	160	Pergola	9/12/2004	5743	17.09	26/05/2005
9	175	Pergola	2/12/2004	10125	16.25	26/05/2005
10	40	T-bar	29/11/2004	5670	16.84	12/05/2005
11	20	Pergola	27/11/2004	7255	15.79	16/05/2005

Organic Hayward

Orchard	Altitude	Growing structure	Full bloom date	Average yield (trays/ha)	Highest DM result (average DM%)	DM sample date
2	15	Pergola	10/12/2004	8423	16.35	30/05/2005
3	30	Pergola	10/12/2004	5020	17.50	11/05/2005
4	20	Pergola	7/11/2004	8284	15.37	14/05/2005
5	120	Pergola	14/12/2004	8440	15.35	08/06/2005
6	130	Pergola	29/11/2004	6676	17.51	03/06/2005
7	110	Pergola	5/12/2004	6801	16.83	04/06/2005
8	185	Pergola	27/11/2004	5012	16.75	11/05/2005
9	175	Pergola	5/12/2004	6190	17.29	31/05/2005
10	40	Mixed	6/12/2004	5024	16.20	06/05/2005
11	20	Pergola	12/12/2004	6186	15.31	02/05/2005

KiwiGreen Hort16A

Orchard	Altitude	Growing structure	Full bloom date	Average yield (trays/ha)	Highest DM result (average DM%)	DM sample date	Year maturity area planted*
2	20	Pergola	23/10/2004	6230	17.73	20/05/2005	1999/00 (grafted)
3	20	Pergola	22/10/2004	10394	19.47	13/04/2005	2000 (seedlings)
4	20	Pergola	3/11/2004	4200	19.56	28/04/2005	2000 (grafted)
5	160	Pergola	4/11/2004	11201	17.64	05/06/2005	2000 (grafted)
6	130	Pergola	28/11/2004	6573	16.69	12/05/2005	2000 (grafted)
7	110	Pergola	26/10/2004	8506	18.20	07/04/2005	1999/00 (seedlings)
8	160	Pergola	2/11/2004	8811	18.02	30/04/2005	2000/01 (seedlings)
9	213	Pergola	2/11/2004	11341	16.99	28/04/2005	1997 (grafted)
10	100	Mixed	1/12/2004	4147	19.95	24/04/2005	2000 (seedlings)
11	40	Pergola	30/10/2004	7369	16.73	20/04/2005	1997/98 (grafted)

* Other parts of the orchard may have been planted at different times

3.0 Environment

3.1 Introduction

The environmental research programme aims to clarify the environmental impacts of different farming or production systems to assist in the identification and subsequent implementation of more sustainable and resilient farming systems. In the past 12 – 18 months, a baseline ecological survey of the ARGOS farms has been undertaken which identified landforms and habitats. This was supplemented by biodiversity surveys of bats, birds, lizards, frogs, fish, insects, soil biota and plants. These surveys acted as a test of monitoring methods and the information obtained will assist in the selection of a small group of 'focal species' for efficient long-term monitoring. These will be species judged to be particularly important to farming and ecological processes in farmscapes, for example species that provide ecosystem services (pollination, soil formation, predator biocontrol, seed dispersal), ones that are important pests, or ones that are especially loved and valued by the farmers or kaitiaki ('flagship' or 'taonga' species). As it is not possible to measure all the biodiversity on farms, it is important to choose focal species that are practical to measure, reasonably common and widespread, and particularly sensitive indicators to ecological practice. A check for threatened species was also undertaken and if they were identified special monitoring and management was suggested to help the farmers to find ways to nurture the populations without undue disruption to normal farming practice.

This research programme recognises that ecological processes and biodiversity on New Zealand's farmed landscapes have received very little study so far. In addition to monitoring the effects of different farming systems this research will also study general ecological processes in farm agro-ecosystems. This research will provide an understanding of why the indicators are changing or not. Identifying the reasons for the observed changes or lack of them is the key to better advice on how to bring the desired improvements in sustainability and resilience.

The environmental research team wants to help farmers assert their rightful place as stewards of the land and build their capacity to make a contribution to reducing the present decline of indigenous biota. ARGOS will also focus on defusing a damaging divide between some regulatory agencies and farmers by facilitating dialogue, sharing information and creating tools that build mutual respect and co-operation between land owners and regional councils and national institutions (MAF, DoC, and Ministry for the Environment).

This section presents some of the environmental findings for ARGOS orchards from the last 12 – 18 months.

3.2 Macro-invertebrates (cicadas and spiders)

One of the major goals of ARGOS is to identify how different ways of farming impact on the environment. To achieve this, it is necessary to first identify indicators of environmental health like plants or animals. ARGOS cannot measure everything, so it has to start by selecting a few potential 'indicator species'. In kiwifruit, cicadas and spiders were identified as potentially telling us something about the impacts of management. It makes sense to choose a pest like cicadas because it may indicate whether the environment is being affected plus it may be possible to identify a control at the same time. Orchard management may indirectly affect spider numbers by altering prey abundance or habitat suitability. For example, composting may increase the numbers of insects and in turn spiders. Spiders therefore seem suitable as an environmental indicator.

In 2004 and 2005, the relative abundances of cicadas and web-spinning spiders in all 30 Bay of Plenty orchards were measured indirectly by counting cicada skins and spider webs in each orchard. For spider monitoring, the number of cicada skins was counted on the posts and trunks of sample vines only as it would have been too time consuming to do any more than this (one of the characteristics of a good indicator is that it should be something that can be measured quickly). The number, type ("orb", "net" or "strand") and approximate locations of webs were counted on each sample vine. Each orchard was sampled in exactly the same way and at similar times so that a valid comparison of relative abundance could be made. In 2004, the orchards were mostly sampled after harvest while in 2005 they were all sampled before harvest.

The average results for each management system are presented in Figure 3.

The major findings were as follows:

- In both 2004 and 2005, the Hort16A orchards on average contained much less spider webs and cicada skins than the other two orchard types;
- On average, more cicada skins were found in KiwiGreen Hayward orchards than in Organic orchards in both years;
- In both years, on average, the number of spider webs per vine did not differ much between KiwiGreen and Organic Hayward orchards;
- There was no clear evidence to demonstrate an impact of altitude or sample date on cicada abundance.

Our indications of differences between the numbers of cicadas and web-spinning spiders suggest that the abundance of species is affected by how kiwifruit is grown. However, the reasons for these differences are unclear and will be explored in the coming years.

Figure 2. Cicada skins (left) and spider webs (right) on kiwifruit vines.

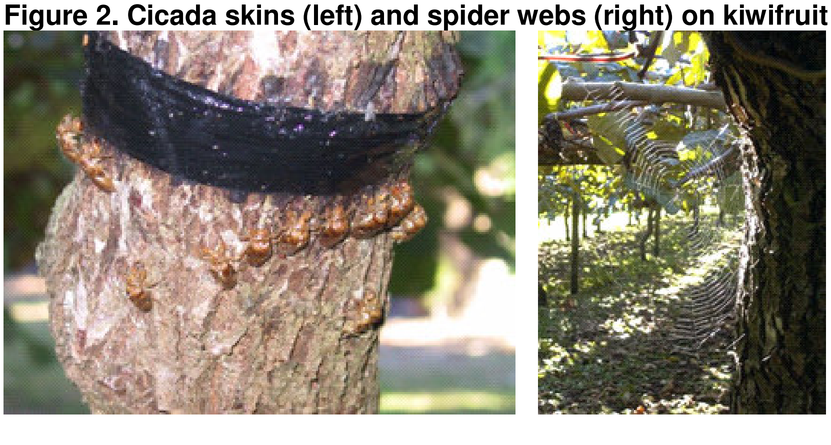
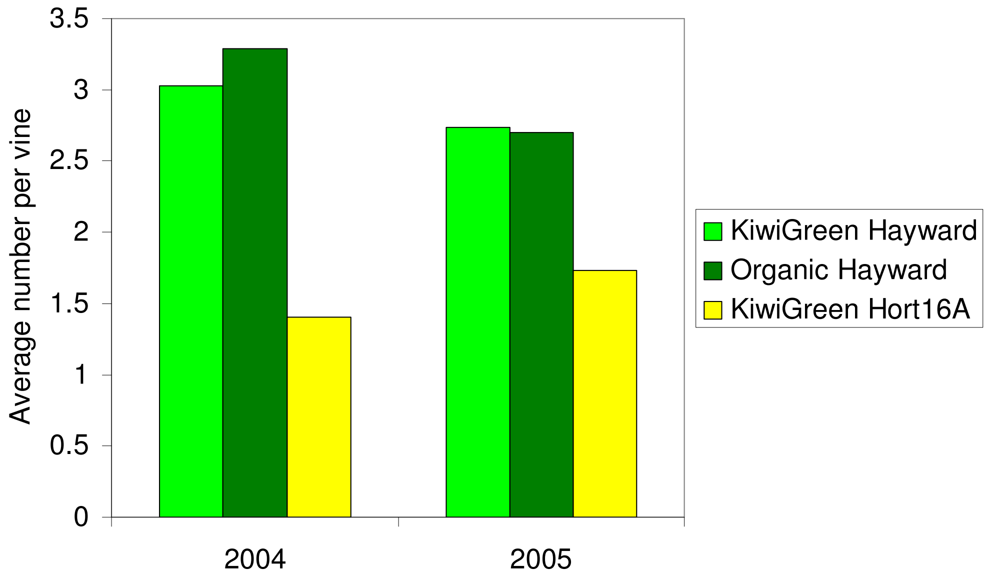
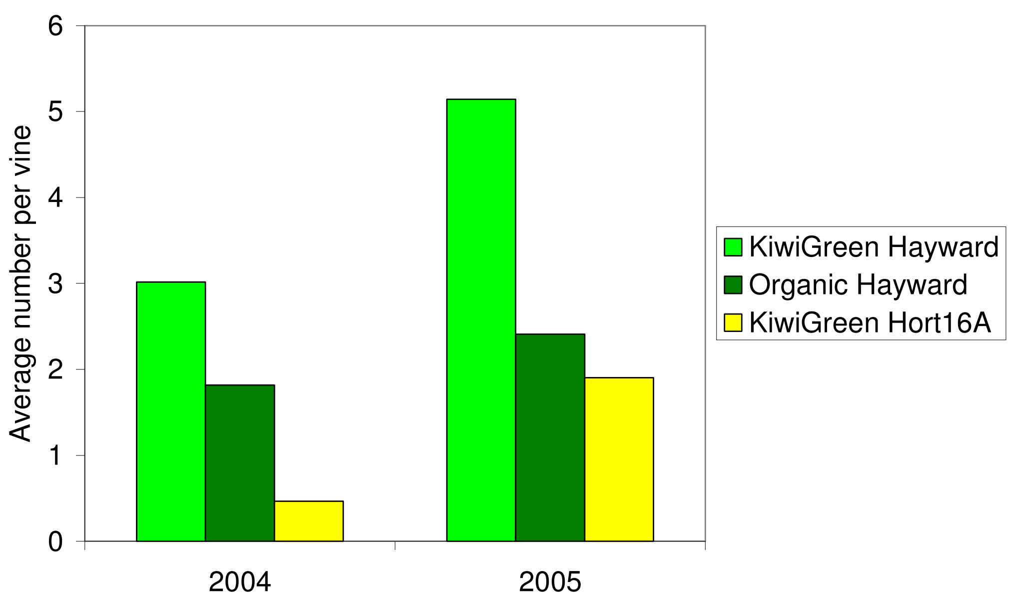


Figure 3. Average number of spider webs (a) and cicada husks (b) found on ARGOS orchards under each management system.

a) Spider webs



b) Cicada husks



3.3 Orchard biodiversity – birds, bats, fish, and lizards

Introduction

This section summarises baseline surveys of birds, fish and bats that were carried out on ARGOS orchards in the summer of 2004/05. A full description of these will be available on the ARGOS website or from the Field Manager (Jayson Benge).

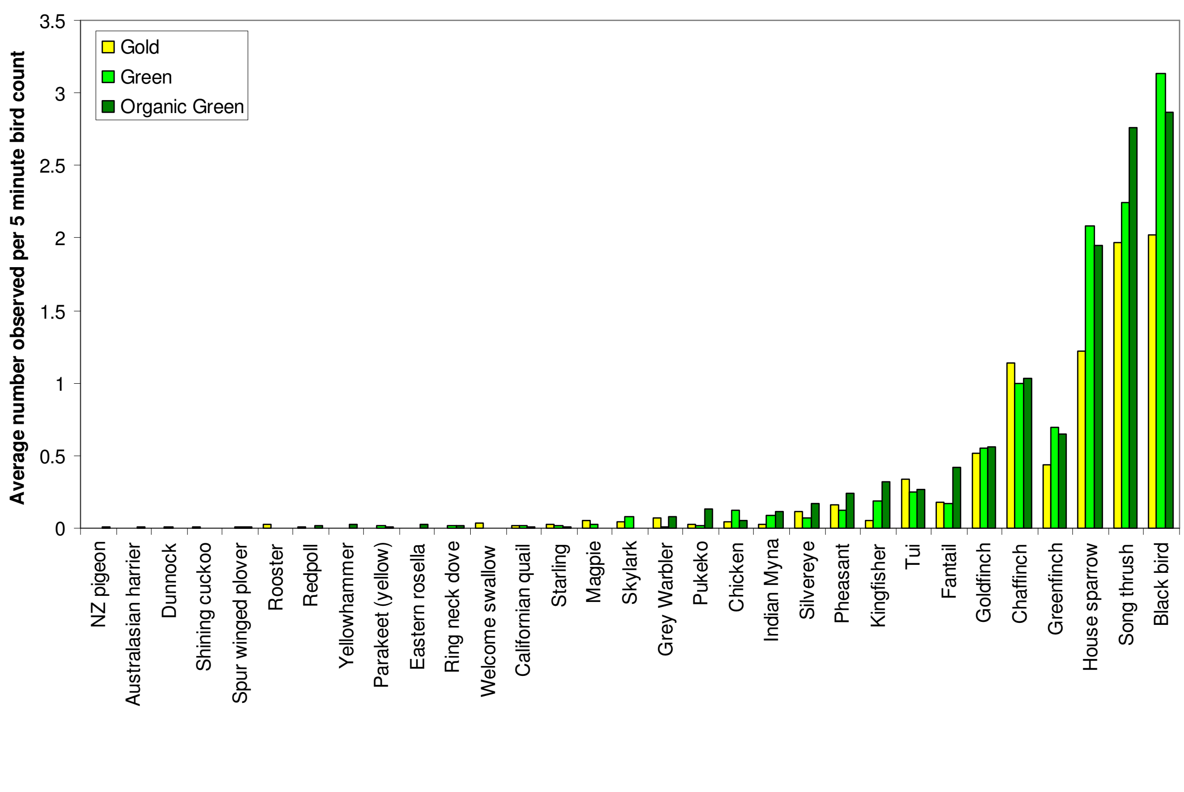
Birds

The relative abundance, diversity and densities of bird species were determined on all the ARGOS orchards during the summer of 2004/05. Two approaches were used; 1) Five minute bird counts where all birds seen or heard over a five minute period are recorded at a particular location 2) Distance sampling where the observer notes the distance out from a predetermined transect line, or from a fixed sampling point, each individual bird or flock is seen.

Each orchard was sampled just once but over 2 – 3 consecutive mornings (when birds are in chorus).

The relative number of birds observed during the 5 minute bird counts across all ARGOS orchards is illustrated in Figure 4 below. The most common species observed across the different orchards were **blackbird, song thrush, house sparrow, finches and fantail**. Species like NZ Pigeon, Australian Harrier, Dunnock and Shining Cuckoo were the least common on orchards.

Figure 4. Relative number of birds found on ARGOS kiwifruit orchards.



Freshwater fish and frogs

As part of the larger biodiversity survey carried out on all ARGOS orchards, fish and other aquatic species were surveyed in ponds and streams where they were present on orchards. This involved spotlighting at night and the use of traps. Small fish traps were set in the evening and checked the following morning, with any fish caught identified, counted and then released.

Only 8 of the 36 ARGOS orchards were found to contain freshwater within their boundaries. Species of fish found included **eels (shortfinned), Inanga, Banded Kokopu, Freshwater Crayfish** and **Freshwater Shrimp** (see appendix 1 for more details on these). Bell Frogs were prevalent on one organic orchard.

Bats

Like birds and fish, surveys for New Zealand's two bat species were also conducted on all ARGOS orchards. This involved night time searches by researchers using specialised bat-detectors, which pick up the echo-location calls of bats as they fly. These detectors were operated at two different frequencies to detect both short-tailed and long-tailed species of bats. Each orchard was scanned in a single night, with a researcher walking around all the shelterbelts on the orchard, and along any road frontage present on the orchard.

No bats were found on any of the 36 ARGOS orchards.

Lizards

In the summer of 2004, artificial cover objects (ACO) or "lizard lounges" were place in all three orchards in two clusters as a pilot trial to look for the presence of lizards (Figure 5). Two types of ACO, made of either brown Onduline roofing material or concrete, were used side by side with 10 of each located in each orchard; 5 were placed on the ground at the ends of kiwifruit blocks (amongst the end assemblies) and 5 were placed on the ground at the base of shelterbelts. The ACOs were generally placed in sunny positions. On each occasion that the ACOs were checked, any overgrown plants were removed to minimise shading.

No lizards were found on any of the 6 sample orchards.

Figure 5. Concrete (left) and Onduline (right) artificial cover objects used for testing the presence of lizards in kiwifruit orchards.

3.4 Soils

3.4.1 Soil quality on ARGOS kiwifruit orchards 2004-2005

Soil quality is highly sensitive to land management practices. Accordingly, monitoring soil quality is a key component of the environmental objective of ARGOS. The prime aims of this monitoring are to identify and characterise any differences in soil quality between agricultural sectors (e.g. kiwifruit, dairy, sheep and beef) and between different farm management systems. In the case of the kiwifruit orchards studied, those management systems are KiwiGreen Hort16A (often referred to and marketed as ZESPRI™ Gold), KiwiGreen Hayward, and Certified Organic Hayward. Here we report the first set of results for soil quality monitoring of the ARGOS kiwifruit orchards which was carried out in 2004.

A suite of measurements was made on all ARGOS orchards between July and September 2004, with the intent to repeat this monitoring regularly for at least five and maybe up to 20 years. Changes in soil quality over time will be compared between management systems and where possible between agricultural sectors.

Soil quality varies a great deal within landscapes, farms and paddocks. Accordingly, a systematic soil sampling regime was developed based on clearly defined levels of focus. Thirty seven kiwifruit orchards are being studied. These are grouped into 12 clusters, with three orchards per cluster: one KiwiGreen Hort16A, one KiwiGreen Hayward, and one Certified Organic Hayward. Those three orchards are as close together as possible to minimise environmental and soil differences. Cluster one is in Kerikeri, cluster twelve in Motueka. The rest are located in the Bay of Plenty. There is a fourth property in the Kerikeri cluster (Hayward converting from KiwiGreen to Organic) which increases the number of properties to 37.

For the work on sheep and beef properties in the ARGOS programme, the approach is to monitor the two most dominant landforms on hill country clusters. An analogous approach is taken with kiwifruit, except that the two dominant "landforms" studied are the areas under the vine and between the rows. These are distinguished in order to understand the effect of management practices on soil across the entire orchard, not just the soil under the vines. Management of these areas can be very different.

Given the large spatial variability in soil quality, samples are taken from three separate blocks (or management units) on each orchard. The same blocks will be measured each time. There are three soil monitoring sites (SMS; each the size of two bays) within each block from which all samples will be collected each time. Each SMS includes sampling areas for the two landforms referred to above.

A range of qualitative and quantitative soil quality indicators were chosen and prioritised. These form a suite of chemical, biological and physical tests made in the field and laboratory. Indicators in priorities one to three are being monitored on a regular basis at all sites.

Priority one measurements include visual assessments of soil porosity, aggregation and area of damaged and bare soil, plus quantitative measurements of bulk density and earthworm populations. The indicators can be used individually or integrated subsequently into one or more soil quality scores. The samples for this are at the level of soil monitoring site.

Priority two measurements are soil chemical analyses for the topsoil (0-15 cm). They are mostly a suite of standard soil measurements with some additional measurements useful for interpretation. The samples for this are collected at the level of block.

Priority three indicators relate to soil biological activity, and use the same samples that are collected for priority two measurements. The measurements are microbial biomass carbon, basal respiration, and the ratio between these two parameters (a useful indicator of the efficiency of the microbial population).

Our interpretation of the data available so far is limited to a preliminary comparison between management systems and landforms. More detailed interpretations and a higher level synthesis are not yet possible for two main reasons. First, the ARGOS approach is to identify robust conclusions on the basis of carefully repeated measurements over several years. Second, full interpretation of soil quality differences will not be possible until detailed information is available on the bases for selection of the individual properties, plus historical and current management practices.

Nevertheless the results so far show some interesting and exciting trends particularly when Organic Hayward and KiwiGreen Hayward orchards are compared:

- Soil **bulk density** was less and porosity was greater for organically managed orchards;
- Soil **pH** was highest on the organically managed orchards, although there was no indication pH would have limited crop production or soil biological activity on any orchard;
- Soil **cation exchange capacity** was higher for organic orchards - a tendency that may well be due to differences in soil pH;
- Organic orchards generally had more **calcium** (Ca) and **magnesium** (Mg);
- Organic orchards generally had more potentially **mineralisable N**, and **biomass** C;
- **Olsen P** was generally less on the organic orchards;
- Generally, the **microbial** population size and activity was highest in the organic Hayward orchards and lowest in the KiwiGreen Hayward orchards;
- **Earthworm** populations were highest on organic orchards and least in the KiwiGreen Hort16A orchards.

There were also some significant differences between landforms and interactions between landforms and management system:

- In terms of **soil structure**, the soil between rows was much less porous than soil within rows particularly on the organic orchards. Similarly, soil between the rows was not as well aggregated as soil within the row, particularly on the KiwiGreen Hort16A orchards. These differences could be due to orchard vehicles damaging soil structure, and understorey vegetation which will contribute to improved soil aggregation through rooting action.
- On the KiwiGreen orchards, we found more **earthworms** between the rows than within the rows which caused an overall landform effect of more earthworms between the rows. Earthworm populations did not differ significantly between landforms on the organically managed properties.
- Under all management systems, **Olsen P** was higher within the row than between the row. This is most likely an effect of fertiliser placement under the vine and P uptake by vegetation growing between rows.
- There was more exchangeable **calcium** between the rows than within the rows in the KiwiGreen orchards, which caused an overall landform effect. There was no difference between landforms in organic management system.
- For magnesium, there was a highly significant interaction effect of management and landform which was driven by high soil **magnesium** levels within the row on organic orchards.

- For **potassium**, there was a strong landform effect and landform by management interaction i.e. the KiwiGreen orchards (both Hayward and Hort16A) had higher soil potassium levels between the row than within the row; the reverse was the case for the organic orchards.
- Sulphate **sulphur** did not differ significantly between the main factors (management or landform). However, there was a significant interaction between management system and landform ($P<0.05$) with sulphate sulphur higher between the row than within the row on organic orchards.
- Averaged across all management systems, there was more soil **organic carbon** between the rows than within the rows.
- The amount of **mineraliseable-N** was higher between the row than within the row for all management systems.
- Under both KiwiGreen management systems, there was more **total N** between the rows than within the rows. This contributed to an overall effect of higher N between the rows.
- Under all forms of management, the size of the **microbial population** was higher between the rows than within the rows with the difference being greater for the KiwiGreen management system. On the KiwiGreen orchards, this difference could be attributed to less organic matter inputs due to herbicide use within the row. For the organic orchards, this result supports our suggestion that the single-time measures of orchard ground cover may be misleading.
- Our results show that basal respiration (a measure of **microbial activity**) was higher between the rows than within the rows for all management systems.

Many of these trends may reflect differences in nutrient budgets and management of under storey vegetation as well as differences between orchards in their previous land use and time under kiwifruit. It is imperative that further information on such factors is used in the interpretation of our results before they are used to form recommendations to the industry. Detailed records of fertiliser applications and orchard management are currently being gathered and will be linked to farm maps and a GIS database.

In further analysis, another factor that should be considered is whether the differences in soil chemical or biological properties expressed on a per unit mass basis are still expressed when the results are converted to kg per ha. Nutrient amounts expressed on a per unit area basis have considerable utility for ecological or crop production studies, although growers and consultants often cannot interpret them for their own purposes. The lower soil dry bulk density of organic properties may mean that the apparent differences in Ca, Mg, N and biomass C per unit mass of soil may be less or non-existent when expressed on a unit area basis.

Further attention needs to be placed on the contrasts which were observed between the soil within the rows and between the rows. Again much more information on site management and history is needed here, but the ecological implications of the strong differences observed suggest that the effort will be well worthwhile.

Overall, it is clear that there is a great deal of scope for more detailed analysis and interpretation of these results. While much of that is well beyond the monitoring brief and budget of the ARGOS soils programme, the quality and value of the information that could emerge are sufficient to justify the considerable extra effort and expense.

3.4.2 Nematodes

The following excerpt is from the ARGOS Newsletter No. 3 (July 2005).

Part of the ARGOS research programme involves identifying orchard characteristics that can be used to monitor changes within and between management systems. Sarah Richards' (nee Spalding) research explores the potential for soil fauna, and specifically nematodes, to act as bioindicators in kiwifruit orchards. Soil fauna and the processes they regulate are essential to the health of soils and to the overall agro-ecosystem. It was important to first understand how growers felt about soil fauna, so a literature review to see what is being printed and read about soil fauna has been carried out. The second part of the research investigates abundance and diversity of nematode assemblages underneath the kiwifruit vines.

Nematodes are small worm-like animals (Figure 6a) that dwell in the soil, feeding on bacteria, fungi, plants, other soil fauna and even each other! Collecting and identifying them is now complete, and Sarah is now in the process of analyzing the results. A preliminary interpretation of the data shows that there is not much difference in the nematode assemblages between KiwiGreen Hayward, organic Hayward, and KiwiGreen Hort 16A kiwifruit orchards. Further analysis is necessary to be certain. Sarahs' research will be finished by the end of August, so read the next newsletter to find out the results!

3.4.3 Soil invertebrates

The following excerpt is from the ARGOS Newsletter No. 3 (July 2005).

Kate Hewsons' Honours project is investigating the biological activity of the soil in kiwifruit orchards and how this varies under the different management systems: Kiwigreen Hayward, Organic Hayward and KiwiGreen Hort16A. Additionally, she is investigating whether differences occur within rows and between rows of kiwifruit and how the biological activity changes with distance from shelterbelts. The data collection was carried from January 18 - February 21, 2005. The bait-lamina test was used; this is a very quick and simple means of studying biological activity in the upper soil layers. It consists of inserting plastic strips (about 160 mm long and 1.5 mm thick; Figure 6b) vertically into the soil and leaving for 3 days. The strips have 16 holes which are filled with a feeding substance composed of carbon, cellulose and bran. After about three days, the strips are removed and the bait disappearance rate, or the proportion of holes eaten, was recorded. At this stage the statistical analysis for these experiments is underway.

Figure 6. Nematode (*Helicotylenchus* sp.) at 40x magnification from one of the ARGOS orchards (a) and bait lamina strip being inserted into the soil (b).

a)

b)

3.5 Insects and mites

Insects and mites on ARGOS kiwifruit orchards

David Steven and Jayson Benge

Introduction

In the 2004/05 season, a baseline survey of canopy invertebrates was undertaken on ARGOS orchards. The aim was to identify possible indicator species which could be easily used to discern the impacts of the different management systems being studied (KiwiGreen Hayward, Organic Hayward and KiwiGreen Hort 16A) on invertebrate diversity and abundance. Pest, beneficial and incidental species were surveyed.

Specifically, a search of leafroller caterpillars was conducted across all ARGOS clusters between late October and late December 2004 (the timing was just before the application of sprays specifically aimed at leafrollers). In February and March of 2005, leaf samples were collected from all clusters except the Motueka one. All insects and mites found were counted and identified to the level of group or species. The key findings are reported here.

Results

1. Leafrollers

Only at Kerikeri, the last site sampled (20.12.04), were significant numbers of caterpillars found. Most caterpillars found were black-headed leafrollers (*Ctenopseustis obliquana*, 77%) or black-lyre leafroller (*Cnephasia jactatana*, 18%). A parasitism rate of only 5.3% was recorded and involved only the tachinid fly (*Trigonospila brevifacies*) with no parasitic wasps found. **Most caterpillars were collected from Organic orchards but this probably largely reflects spraying of broad-spectrum pesticides against scales prior to the sampling in KiwiGreen.**

2. Foliar Faunal Survey

Overall infestation

Most leaves which were examined had an insect or mite present, with mites the more common. **Overall, a significantly higher infestation of <u>insects</u> was found in Organic orchards compared to either KiwiGreen system**. However the overall infestation of mites did not differ among the management systems. Overall, there were significant differences among the clusters (i.e. location) for mite infestations but not for insects. For insects and mites combined, the variation among management systems was significant, while that among clusters was almost significant.

Table 3 presents the average infestation rates for each of the management systems.

Table 3. Average amounts of insects and mites found on ARGOS orchard for each management system.

	Averages for ARGOS orchards*		
	KiwiGreen Hayward	Organic Hayward	KiwiGreen Hort16A
Overall (% of leaves infested)			
- insects	39	67	47
- mites	68	80	83
- insects or mites	79	92	91
- live armoured scale	8	22	7
- greenhouse thrips	7	13	10
Insects (number per 50 leaves)			
- live armoured scale	5.0	23.5	5.1
- greenhouse thrips	6.1	12.5	16.8
- soft scales	0.7	0.8	2.5
- Collembola (springtails)	0.5	0.4	0.1
- small beetles	1.3	1.2	2.5
Mites (number per 50 leaves)			
- predator mites	26.8	50.5	54.5
- tydeid mites	62.3	1.9	91.0
- Czenspinksia mites	11.1	62.9	8.8
- acarid mites (mould mites)	0.9	10.1	0.9
- tarsonemid mites	4.6	3.0	0.7
- oribatid mites	3.7	5.9	6.7
- six-spotted mites	1.3	0.1	0.5

* Excludes data for the 3 orchards in Motueka which were not able to be sampled.

Psoccids (Booklice)

The most common insect group present on kiwifruit leaves were psoccids or booklice which feed on detritus (debris) and fungal matter. These are incidental insects that are part of the general cycling of plant material and hence nutrients.

Armoured scales

The second-most common insect group were the armoured scales. In spite of the small number of leaves examined for each orchard, only 50, armoured scales were found in all but 2 of the 34 orchards sampled. **Significantly more scales were found in Organic orchards than in the KiwiGreen orchards**. There was also significant variability among the clusters (i.e. location) but not in any obvious pattern. **Note that the average infestation level for each management system was over the minimum spray threshold of 4%, and that 5 Organic and 1 Hort 16A KiwiGreen orchards were over a 10% level in this survey.**

Scale parasites were only found on Organic orchards, being recorded on 4 of the 11 established organic orchards. However, this may be a result of the higher numbers of scales found on these orchards rather than because of any adverse impact of the broad-spectrum sprays still used against scales on KiwiGreen orchards. On those orchards where parasites were found, the average rate of parasitism was 11.4%, with a range of 4% - 20%.

Minor pests

Greenhouse thrips, both adults and larvae, and their damage were also common on the leaves. One Hort 16A orchard had 177 thrips on its 50 leaves, a level which is probably of concern. Another 4 orchards had more than 25 thrips per 50 leaf sample. The variability among orchards meant that no significant differences between management systems were found for this or for any of the other minor pests.

Soft scales (largely immature black scale; *Saissetia oleae*) were found on 19 of the 34 orchards examined, although levels were low on all except one Hort 16A orchard which had 20 on its 50 leaves. Soft scales are cosmopolitan pests on other fruit crops and produce copious honey dew which gives rise to sooty moulds on fruit.

Collembola or springtails (*Xenylla maritima*) were present in small numbers in samples from 8 orchards. These small insects are detrital feeders and should not be considered pests although previously fruit contaminated with Collembola has caused quarantine problems. Small beetles of several detrital and fungal feeding species are found on kiwifruit. Again these have previously caused some quarantine problems and are mainly contaminants although in China one species is thought to cause fruit marking on kiwifruit. As most of the specimens found were larvae, which cannot be readily identified, all small beetles were grouped together. They occurred on over half of all orchards (18/34), with moderate numbers on two.

A single mealybug, a pest of current quarantine concern for the Japanese market, was found in each of 2 samples, one from a KiwiGreen Hayward orchard and the other a KiwiGreen Hort 16A orchard. Both were in the Te Puke area.

Mites

A range of mites were present on the leaves, some being numerous. There were significantly fewer predator mites on KiwiGreen Hayward orchards than either other management system, which both had similar levels. There were no differences among clusters (i.e. location) for this or any other mite group. Tydeid mites, detrital feeders, were the most abundant mite on either type of KiwiGreen orchard but were almost entirely absent from Organic orchards. The reverse applied to both *Czenspinksia* and acarid mites, two other groups of detrital feeders. Both these mites were significantly more abundant in Organic orchards than in either KiwiGreen system. Numbers were similar for each variety under KiwiGreen management. Significantly more tarsonemid mites, which are very small and feed on detritus or fungi, were found on KiwiGreen Hayward than on KiwiGreen Hort 16A, with Organic levels intermediate but somewhat closer to those on Hayward KiwiGreen. Oribatid mites, a diverse group of mites about which little is known, were more uniformly present in all samples, and showed no significant differences among management systems. Six-spotted mites were found on 9 of the 34 orchards, but only in low numbers, too low to show any differences. This spider mite is a very serious pest on avocados in New Zealand. It was common on kiwifruit in the 1970s, but not noted since that time.

Conclusions

The foliar faunal survey showed that the abundance of a number of insects and mites varied with management system in spite of the small sample of leaves used. Mites were particularly useful in this regard. Armoured scales were more common in Organic orchards than in either type of KiwiGreen orchard. This was not surprising. However, **the range in scale levels within each management system shows the strong potential to improve control on some orchards regardless of whether they are Hayward or Hort 16A, Organic or KiwiGreen.** Most of the minor pests were not common enough to reveal any possible differences relating to management system. However the abundance, albeit sporadic, of some is a warning bell that they should not be ignored e.g. greenhouse thrips, soft scales and six-spotted mites.

The presence of differences among non-target organisms such as mites clearly demonstrated that each of the 3 management systems did create a distinct environmental impact or footprint. Further work is required to try to link relative abundance to specific management practices such as choice of sprays. Without such linkages, the relationship of any potential indicator to resilience or sustainability remains problematic.

3.6 Habitat report – work in progress

Currently, ARGOS is working on a detailed habitat report. This report describes a preliminary survey of habitats and landforms on 37 ARGOS kiwifruit orchards between May and September 2004. The main aim was to obtain spatial data, using Global Positioning Systems (GPS) and ground measurements, to facilitate the making of maps for the 37 kiwifruit orchards. An additional aim of the survey was to collect for each orchard, information on a range of orchard features deemed to be of environmental interest and significance. A synthesis of main habitat themes and potential research priorities will be included in the report.

Figure 7. ARGOS researchers surveying orchards.

4.0 Economics

Introduction

ARGOS is monitoring and comparing the financial performance of orchards and management systems over several years. This section summarises the financial data collected from for two initial financial years (2002/03 and 2003/04). ARGOS used a similar approach to that used by the Ministry of Agriculture and Fisheries (MAF) for its farm monitoring. For many of the orchards, the financial data was obtained directly from the owner's set of financial accounts with help from the owner. In other cases, the owner provided other sources of financial data like fruit payment statements and invoices. Where specific data was not available, some assumptions had to be made under the guidance of the owner. In a few cases, industry averages were used where no data was available. Every effort has been made to ensure that the data presented here is as accurate as possible.

Results

The financial data for ARGOS orchards is currently being analysed to identify any significant differences between and within management systems. As a broader comparison, Industry OGR figures are presented in Figure 8 below.

Figure 8. Comparison of Industry OGR (Source: Kiwiflier, July 2005)

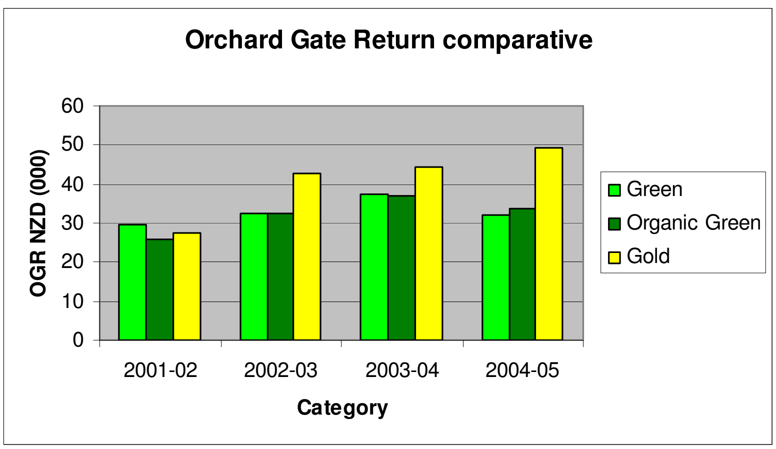


Table 4 below provides the average and median financial results for each of the different management systems. Results from the MAF Farm Monitoring Scheme have also been included to provide you with a broader basis to compare your performance. More detailed MAF Farm Monitoring data can be downloaded from the MAF Website (www.maf.govt.nz) or obtained from your Field Manager. **Table 5 provides total revenue and expenditure for each ARGOS orchard in the Bay of Plenty** (data for the 3 orchards in each of Motueka and Kerikeri has not been presented as it may be possible for the participating orchardists in those regions to identify each others data). Differences between orchards are due to differences in factors like:

- the levels of inputs especially labour (some orchardist do a lot of the work themselves which has no direct cost);
- the age of the Hort16A crops
- items like frost protection and modifications to planting structure (which contribute to the orchard expenditure)
- type of management i.e. some orchards are managed by packhouses which impacts on costs (as some costs are shared over several orchards).

Table 4. Average and median financial data for each management system.

	Your Orchard					
	Per canopy hectare ($)			Per export tray ($)		
	2002/03	2003/04	MAF 03/04[1]	2002/03	2003/04	MAF 03/04[1]
Gross Orchard Revenue (GOR)	26,899	30,811	44,705	5.50	6.24	6.87
Cash Orchard Expenditure (COE)	12,245	13,626	22,834	2.50	2.76	3.51
Operating Surplus (GOR-COE)	**14,653**	**17,184**	**21,871**	**3**	**3**	**3.36**
COE / GOR	45.5%	44.2%	51.1%	45.5%	44.2%	n/a

	ARGOS averages for each management system								
	Kiwigreen Hayward per ha ($)			Kiwigreen Hort16A per ha ($)[2]			Organic Hayward per ha ($)		
	2002/03	2003/04	% change	2002/03	2003/04	% change	2002/03	2003/04	% change
Gross Orchard Revenue (GOR)	32,986	44,860	36.0%	39,695	38,937	-1.9%	33,280	37,716	13.3%
Cash Orchard Expenditure (COE)	15,933	20,232	27.0%	19,321	23,794	23.2%	13,950	15,994	14.7%
Operating Surplus (GOR-COE)	**17,053**	**24,628**	**44.4%**	**20,374**	**15,143**	**-25.7%**	**19,331**	**21,722**	**12.4%**
COE / GOR	48.3%	45.1%	n/a	48.7%	61.1%	n/a	41.9%	42.4%	n/a

[1] MAF = Ministry of Agriculture and Fisheries (MAF) farm montoring framework. Data based on a model orchard consisting of 0.5 hectares of Kiwigreen Hort16A and owner-operated.

[2] Average figures are based on 6 out of the 12 gold orchards as the accounts for the Gold data was seperated from other kiwifruit varieties.

	ARGOS Averages						
	Kiwigreen Hayward		Organic Hayward		Kiwigreen Hort16A[3]		MAF 03/04
	Average	Median	Average	Median	Average	Median	Average
Canopy Hectares	3.97	4.46	3.77	3.57	3.10	2.58	4.5 Green & 0.5 Gold
Export trays/ha	6,888	6,030	4,519	5,318	5,547	5,899	6400 Green & 7500 Gold
Revenue							
Green - OGR progress	41,651	38,270	35,185	39,290	n/a	n/a	38,400
- previous crop final	1,935	2,065	2,230	2,068	n/a	n/a	2,822
Gold - OGR progress	n/a	n/a	n/a	n/a	36,129	39,590	51,450
- previous crop final	n/a	n/a	n/a	n/a	2,519	1,820	3,800
Other fruit crops	1,196	0	0	0	0	0	900
Rebates/hire	78	0	302	5	347	0	1,180
Gross Orchard Revenue	**44,860**	**39,646**	**37,716**	**41,855**	**38,937**	**42,044**	**44,705**
Orchard Working Expenses							
Wages							
Wages	7,555	7,794	5,207	4,501	12,701	15,384	10,500
Picking Wages	2,910	2,000	1,449	1,527	1,815	1,838	1,758
ACC	328	113	333	437	128	132	496
TOTAL	10,793	9,907	6,989	6,465	14,644	17,353	12,754
Spray & Chemicals	1,467	1,417	1,176	827	1,551	962	1,300
Pollination	1,375	1,222	816	827	820	808	1,200
Fertliser	1,220	1,005	1,000	827	1,040	1,096	1,200
Vehicle costs	713	732	1,036	1,065	1,256	1,024	1,100
Repairs & Maintenance	2,536	1,794	1,409	901	2,189	1,056	2,120
Admin & Other							
Electricity	73	65	200	133	50	64	180
Rates	477	413	447	407	363	346	600
Communication costs	107	70	277	237	314	357	410
Insurance	262	151	216	208	232	161	370
Accountancy	434	336	430	460	286	185	640
Legal & consultancy	13	0	230	132	168	131	220
Other admin	92	66	413	500	251	135	200
Other expenditure	670	539	1,354	489	2,850	508	540
TOTAL	2,127	1,640	3,568	2,566	4,513	1,885	3,160
Cash Orchard Expenditure	**20,232**	**19,831**	**15,994**	**15,678**	**23,794**	**20,971**	**22,834**

[3] Average figures are based on 6 out of the 12 gold orchards only as the Gold data was seperated from other kiwifruit varie

Table 5. Revenue and expenditure for ARGOS orchards in the Bay of Plenty on a per hectare basis. NOTE - this data pertains to revenue received and expenditure incurred within the 2002/03 (a) and 2003/04 (b) financial years i.e. the data does not relate totally to one crop. For each management system, data is in order of ascending altitude. The Hort16A data is presented in two parts – for orchards with both Hort16A and Hayward (and expenditure not separated) and for orchards with Hort16A only. Data was not available for every orchard and is denoted by a "."

a) 2002/03 Financial Year

KiwiGreen Hayward

			2002/2003							
Orchard	Altitude	Growing structure	Hayward area (ha)	Hort16A area (ha)	2002 Hayward yield (Class I trays / ha)	2002 Hort16A yield (Class I trays / ha)	Hayward revenue ($ / ha)	Hort16A revenue ($ / ha)	Total orchard expenditure ($ / ha)
1	15	Pergola	2.3	0.0	.	.	.	.	.
2	20	Pergola	4.5	0.0	3,302	0	$22,573	$0	$17,580
3	20	Pergola	.	.	.	.	.	.	.
4	26	Pergola	2.2	0.0	7,696	0	$42,285	$0	$15,963
5	40	T-bar	4.6	0.0	7,237	0	$45,047	$0	$12,472
6	80	Pergola	3.0	0.0	7,739	0	$42,914	$0	$23,196
7	140	Pergola	2.3	0.0	4,715	0	$25,360	$0	$14,120
8	160	Pergola	6.0	0.0	3,724	0	$21,583	$0	$14,470
9	160	Pergola	.	.	.	.	.	.	.
10	175	Pergola	4.9	0.0	5,313	0	$31,764	$0	$17,417

Organic Hayward

			2002/2003						
Orchard	Altitude	Growing structure	Hayward area (ha)	Hort16A area (ha)	2002 Hayward yield (Class I trays / ha)	2002 Hort16A yield (Class I trays / ha)	Hayward revenue ($ / ha)	Hort16A revenue ($ / ha)	Total orchard expenditure ($ / ha)
1	15	Mixed	2.4	0.0	.	.	.	.	.
2	20	Pergola	1.8	0.0	5,774	0	$43,015	$0	$19,812
3	20	Pergola	2.6	0.0	6,448	0	$46,039	$0	$19,261
4	30	Pergola	4.0	0.0	4,376	0	$29,846	$0	$10,815
5	40	T-bar	4.0	0.0	5,418	0	$37,620	$0	$12,250
6	110	Pergola	4.1	0.0	5,061	0	$39,617	$0	$14,338
7	120	Pergola	2.0	0.0	4,250	0	$22,872	$0	$18,308
8*	130	Mixed	10.1	0.0	3,467	0	$25,446	$0	.
9	175	Pergola	4.3	0.0	6,835	0	$37,588	$0	$11,835
10	185	Pergola	2.8	0.0	3,460	0	$24,555	$0	$18,327

KiwiGreen Hort16A

	Orchard	Altitude	Growing structure	2002/2003 Hayward area (ha)	Hort16A area (ha)	2002 Hayward yield (Class I trays / ha)	2002 Hort16A yield (Class I trays / ha)	Hayward revenue ($ / ha)	Hort16A revenue ($ / ha)	Total orchard expenditure ($ / ha)	Year of planting	Comments
Hort16A orchards with Hayward	1	20	Pergola	2.4	1.8	6,485	3,597	$16,726	$8,107	$24,151	1999/00 (grafted)	
	2	20	Pergola	1.2	0.8	5,460	1,055	$33,125	$8,037	$9,705	2000 (grafted)	Low wage cost - does not include manager's wages who does a lot of the work
	3	130	Pergola	1.5	0.7	5,005	4,288	$20,417	$7,731	$18,281	2000 (grafted)	
	4	160	Pergola	1.8	1.3	5,922	4,753	$33,690	$18,231	$21,893	From 1997 (new and grafted)	
Hort16A only orchards	5	20	Pergola	0.0	6.5	0	6,270	$0	$33,683	$26,473	From 1997 (new and grafted)	
	6	40	Pergola	0.0	2.0	0	4,609	$0	$27,056	.	1997/98 (grafted)	Managed by packhouse; expenditure data not available
	7*	100	T-bar	0.0	0.5	0	1,377	$0	$9,693	$12,927	2000 (new)	Young, small blocks
	8	110	Pergola	0.0	2.5	0	1,903	$0	$11,633	$10,842	From 1998 (new)	Reasonably low wage cost (owner and family do most work)
	9	160	Pergola	0.0	4.5	0	8,176	$0	$51,428	$24,456	From 1998 (grafted)	
	10	213	Pergola	0.0	2.7	0	9,862	$0	$74,023	$23,644	1997 (grafted)	

* This orchards also contains pergola Hort16A as well as Hayward but data provided for T-bar Hort16A only

b) 2003/04 Financial Year

KiwiGreen Hayward

Orchard	Altitude	Growing structure	2003/2004 Hayward area (ha)	Hort16A area (ha)	2003 Hayward yield (Class I trays / ha)	2003 Hort16A yield (Class I trays / ha)	Hayward revenue ($ / ha)	Hort16A revenue ($ / ha)	Total orchard expenditure ($ / ha)	Comments
1	15	Pergola	2.34	0.00	6,030	0	$41,307	$0	$31,617	Reasonably high wage cost
2	20	Pergola	4.50	0.00	6,397	0	$38,682	$0	$19,854	
3	20	Pergola	2.39	0.00	.	.	.	.	.	Financial data not available
4	26	Pergola	2.16	0.00	6,794	0	$45,290	$0	$14,375	Very low wage cost - owner does most of work
5	40	T-bar	4.46	0.00	5,440	0	$39,646	$0	$16,592	
6	80	Pergola	3.00	0.00	11,000	0	$75,125	$0	$20,913	
7	140	Pergola	2.30	0.00	6,002	0	$32,542	$0	$18,713	
8	160	Pergola	6.20	0.00	6,030	0	$31,500	$0	$19,831	
9	160	Pergola	2.21	0.00	6,052	0	.	.	.	Financial data not available
10	175	Pergola	4.86	0.00	9,360	0	$57,366	$0	$26,563	High R&M cost (orchard converted to pergola)

Organic Hayward

Orchard	Altitude	Growing structure	2003/2004: Hayward area (ha)	Hort16A area (ha)	2003 Hayward yield (Class I trays / ha)	2003 Hort16A yield (Class I trays / ha)	Hayward revenue ($ / ha)	Hort16A revenue ($ / ha)	Total orchard expenditure ($ / ha)
1	15	Mixed	2.78	0.00	4,694	0	.	.	.
2	20	Pergola	1.80	0.00	5,656	0	$46,802	$0	$25,806
3	20	Pergola	3.57	0.00	2,824	0	$27,456	$0	$16,122
4	30	Pergola	4.00	0.00	3,439	0	$28,375	$0	$14,744
5	40	Mixed	3.81	0.00	4,123	0	$32,815	$0	$11,087
6	110	Pergola	4.10	0.00	5,469	0	$47,930	$0	$15,678
7	120	Pergola	2.00	0.00	5,609	0	$45,922	$0	$21,887
8	130	Mixed	10.10	0.00	5,318	0	$40,259	$0	$17,619
9	175	Pergola	4.30	0.00	6,074	0	$48,031	$0	$13,085
10	185	Pergola	2.80	0.00	5,715	0	$42,611	$0	$18,527

KiwiGreen Hort16A

	Orchard	Altitude	Growing structure	2003/2004: Hayward area (ha)	Hort16A area (ha)	2003 Hayward yield (Class I trays / ha)	2003 Hort16A yield (Class I trays / ha)	Hayward revenue ($ / ha)	Hort16A revenue ($ / ha)	Total orchard expenditure ($ / ha)	Year of planting	Comments
Hort16A orchards with Hayward	1	20	Pergola	2.40	1.80	10,705	4,257	$65,111	$27,732	$35,257	1999/00 (grafted)	Significant artificial shelter R&M cost
	2	20	Pergola	1.00	0.75	10,024	2,424	$73,444	$21,070	$12,992	2000 (grafted)	Low wage cost - does not include manager's wages who does a lot of the work
	3	130	Pergola	2.15	1.00	4,510	2,394	$27,706	$15,479	$14,005	2000 (grafted)	Reasonable low wage cost. Packhouse managed.
	4	160	Pergola	1.80	1.30	7,478	4,847	$51,195	$31,825	$30,455	From 1997 (new and grafted)	
Hort16A only orchards	5	20	Pergola	0.00	6.50	0	6,923	$0	$52,530	$35,314	From 1997 (new and grafted)	Significant amount spent on planting structures
	6	40	Pergola	0.00	1.96	0	3,188	$0	$23,160	$17,826	1997/98 (grafted)	Managed by packhouse
	7*	100	T-bar	0.00	0.52	0	5,546	$0	$38,312	$12,927	2000 (new)	Young, small blocks
	8	110	Pergola	0.00	2.50	0	3,171	$0	$23,571	$11,356	From 1998 (new)	Reasonably low wage cost (owner and family do most work)
	9	160	Pergola	0.00	4.48	0	8,199	$0	$45,775	$24,117	From 1998 (grafted)	
	10	213	Pergola	0.00	2.65	0	6,251	$0	$48,537	$41,224	1997 (grafted)	Expenditure includes high frost protection cost ($30K)

* This orchards also contains pergola Hort16A as well as Hayward but data provided for T-bar Hort16A only

5.0 Total energy indicators

Why measure total energy use?

There are several key drivers for wanting to improve our knowledge on energy efficiency and related climate change issues:

1. Improve profitability (particularly as energy costs continue to soar)
2. Protect and enhance NZ's 'clean green image'
3. Market access issues (food miles)
4. Assist NZ to meet its Kyoto Treaty obligations

Total energy use, including not only fuel but the energy embodied in the manufacture of all orchard inputs, is an important measure of an orchards overall sustainability. Benchmarking performance can highlight areas for improvement, as well as gaining a better understanding of the on-orchard environmental impact compared to other parts of the food chain like transport.

In 2005, information was collected for each of the ARGOS kiwifruit orchards which would allow us to estimate the energy use in the 2003/04 production season. Average total energy use across all three management systems (KiwiGreen Hayward, KiwiGreen Hort16A and Organic Hayward) was similar on a per hectare basis. The only standout difference was liquid fuel use by Hort16A orchards, which accounted for 4 of the 5 highest fuel using orchards. The story changes when viewed on a production basis, where the lower producing organic orchards have the largest energy footprint.

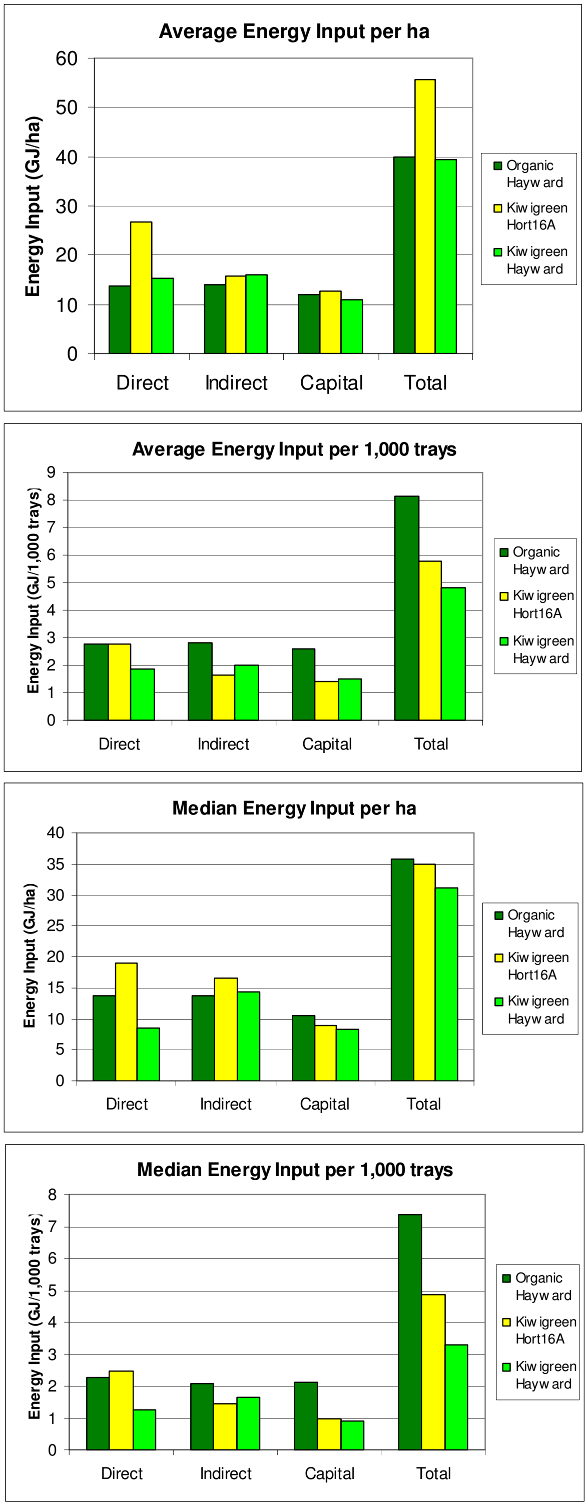
For the KiwiGreen orchards approximately 75% of the indirect input is fertiliser (mainly nitrogen). For the organic orchards 25% is fertiliser and the rest is predominately oil sprays. At this stage we have assumed that 95% of the energy embodied in the organic agrichemicals results from formulation, packaging and transport. This needs to be studied further.

The energy embodied in machinery and support structures, makes up 25-30% of total energy use. Further study is needed into this aspect to correctly account for depreciation and those orchards with shared equipment and a large proportion of contractors.

In many cases, it wasn't possible to obtain estimates of electricity use because the participants did not know this. Often machinery that used electricity was shared with other properties or did not have dedicated electricity meters.

The average amounts of energy used in each of the production systems are presented in Figure 9.

Figure 9. Average energy use on ARGOS kiwifruit orchards.



Please note that the number of orchards included in each energy input category (direct, indirect and capital) varies depending on which orchards have completed different parts of the survey. For example some orchards may be included in the average direct input figure but not the indirect and consequently are also excluded from the total.

A gigajoule (GJ) is equal to 1,000 megajoules (MJ). A litre of diesel contains 44 MJ of (primary) energy. So for example an orchard with an energy input of 7 GJ/1,000 trays is equivalent to 160 litres of diesel per 1,000 trays.

6.0 Social

6.1 Introduction

Improving the sustainability of farming involves social, as well as economic and environmental, dimensions. For example, while it is possible to assess the relative viability of farm incomes, the earning potential of a given farm household may reflect issues of succession, retirement objectives, ethical decisions or pressures exerted by family or society more generally. Similarly, whereas the promotion of more bio-diverse farmscapes may appear to involve relatively straight forward decisions regarding resource management, the influence of shared ideas of appropriate farm management or the availability of sufficient skills and labour may limit the feasibility of such decisions. The social research component of the ARGOS project is designed to examine a range of social features, including those identified above, that have been shown to impact the way in which farmers approach farm management and engage with issues of sustainability.

During the past year we initiated our data gathering programme, employing a variety of social research methods. Dr. Lesley Hunt has met with every participant in the Kiwifruit sector in order to conduct the first of our qualitative interviews. You should also have received (and responded to) the first sectoral survey which was sent to you in the post. You may have also completed a 'causal map' under the guidance of Dr. John Fairweather. A second round of interviews focused on the constraints to farm management is planned for early summer. In the meantime, Dr. Hugh Campbell will meet with and interview industry representatives from meat packing, dairy and kiwifruit sectors. With this range of information, we will develop a more comprehensive understanding of the social dimensions of agricultural production. This knowledge, in turn, will contribute to our assessment of sustainable farm/orchard management in New Zealand.

6.2 Results of the first qualitative interviews

Executive summary of the first kiwifruit qualitative interviews

Lesley Hunt[1], Chris Rosin[2], Carmen McLeod[2], Marion Read[1],
John Fairweather[1] and Hugh Campbell[2]

In the first interview undertaken in the kiwifruit sector of the ARGOS programme, participants were asked a series of questions in order to record their initial ideas about topics of interest to the management, environmental, economic and social objectives of the ARGOS programme. The responses to these topics are summarised below under the headings of the questions asked in the interview. If you are interested there is a fuller report available on the ARGOS website (www.argos.org.nz), from Jayson Benge (Field Research Manager), or any of the authors.

The different management systems under study – KiwiGreen Hayward, Organic Hayward and KiwiGreen Hort 16A - will hereafter be referred to as Green, Organic and Gold respectively for the sake of brevity. The term "panel" is used to describe the group of participants associated with each management system.

[1] AERU, PO Box 84, Lincoln University, Canterbury

[2] CSAFE, University of Otago, PO Box 56, Dunedin.

1. What do you call yourself?

There were 17 different answers to this question and 23 (out of the 35 participants) used the word orchardist as part of their title. Seven were Green participants, ten were Organic and six were Gold. Of the six who called themselves managers, four came from Gold orchards.

2. What does your work involve?

This question was usually answered in terms of the work and management associated with the yearly cycle and management practices. These will be very familiar to participants so will not be reported on here.

When the panels were compared, emphasis was given by:
- Green participants to tidiness, mowing, and concerns about use of hydrogen cyanamide (e.g. Hi-cane ™).
- Organic participants to compost but this was not exclusive to them.
- Gold participants to newness and novelty of the Gold variety.

Out of all orchardists, only a few Green participants (3) had changed the way they applied their fertiliser due to environmental concerns.

3. Personal vision, vision for orchard and constraints to vision

A range of motivations underlie the management strategies of participants in the ARGOS programme. Financially related visions were financial improvement, economic growth, profitability, investment, and financial gain achieved through the sale of property. Others visions included productivity, the move to retirement, spreading the risk through diversification, producing good fruit, lifestyle, and stewardship of the land.

When the panels were compared, emphasis was given by:
- Green participants to vision of financial benefit.
- Organic participants to size of fruit, environmental and soil improvement.
- Gold participants to the orchard as a capital investment, fruit dry matter (DM), lifestyle as a commodity.

Constraints to these visions were related to the climate and physical environment, labour, financial factors such as limited capital, increasing costs, audit requirements, local and national government land use policies, macroeconomic policies/conditions, and personal constraints such as health and lack of skills.
When the panels were compared, emphasis was given by:
- Green participants to limitations in the orchard structure, e.g. t-bar structures compared with pergola.
- Organic participants to limitations imposed by the environment and/or plants (and weeds).
- Gold participants to constraints of capital and lack of knowledge/skills.

4. Orchard maps drawn by participants

Each participant was asked to sketch a map of their orchard and include all the features that they perceived to be important to management. Table 6 presents the frequency of the grouped features drawn on the maps or mentioned during the exercise. Generally, no major differences were found between panels in terms of features that were identified as being important to management.

Table 6. Features on orchard maps drawn and spoken of by participants.

	Feature	Green	Organic	Gold	Totals
Spatial Organisation	Boundaries, blocks	20	22	21	63
Transport	Driveways, roads, loading areas	17	19	17	53
Buildings	Houses, sheds, packhouse	18	20	14	52
Wind	Shelter, prevailing wind, wind damage	17[a]	13[b]	13[b]	43
Water	Streams and rivers, water sources, tanks, irrigation, lakes and ponds, drainage	12[b]	20[a]	6[b]	38
Climate	Frost areas, frost protection, altitude, climate	11	11	11	33
Landscape morphology	Slope, aspect, gullies	10	13	10	33
Other biota	Other crops, trees, compost	7	13	7	27
Social context	Neighbours	7	8	7	22
Biotic context	Bush, *Armillaria*, soils	6[b]	10[a]	4[b]	20
Overall totals		125	149[a]	110[b]	384

Note: ‘a’ and ‘b’ superscripts denote these results are statistically different at the 5% level of significance.

5. Productive and financial wellbeing

Participants thought that their financial returns as measured by capital flow, profit, input costs and returns, told them when they were doing well financially. They considered their orchard’s productivity was measured by benchmarking fruit quality and quantity and certain vine characteristics.
When the panels were compared, emphasis was given by:

- Organic and Gold to relative returns.
- Green and Gold to fruit quality (it was a given for Organic participants).
- Organic participants to vine characteristics.

6. Environmental wellbeing

Orchardists felt that animals and plants indicate environmental health. Views about spray use ranged those who thought sprays damaged the environment to those who felt sprays were not harmful to the environment. Many made comparisons with previous spray programmes before the introduction of the KiwiGreen system.

Soil health was regarded as a way of assessing the environment. This was related to soil appearance and worm life. Most growers relied on ‘experts’ to help them determine soil health.
Specific management systems – KiwiGreen or Organic – were perceived by some as caring for the environment. These systems gave participants a sense of security and a level of confidence. For some ‘cleanliness’ and ‘tidiness’ were linked to caring for the environment. Some saw their role as caretaker of the environment and others did not want their care for the environment associated with being a ‘greenie’.

Observations of animals were described in a variety of ways – as pests, as beneficial to orchard, aesthetic, or just present. The most common animals mentioned by participants at the time of the interview were rabbits (23) and possums (16). The most common invertebrates were worms (15), spiders/spider webs (11), insects (general) (11), and cicadas (10). Lizards were mentioned ten times. The most common birds were pheasants (22), sparrows (20), pukeko (17), fantails (16), blackbirds (16), tui (15), thrushes (15), rosellas (13), quail (11), and wood pigeons (10).

When the panels were compared, emphasis was given by:

- Green and Gold participants to birds as indicators (the introduction of KiwiGreen has improved birdlife).
- Green and Gold participants linked environmental care to cleanliness and tidiness.
- Organic participants to soil health (they see themselves as 'caretakers of the land').

7. Personal, family and community wellbeing

Participants were very enthusiastic about orcharding. They said things like: "I feel good about what I do", "It always gives me a buzz", and "I love it". They usually associated their wellbeing with the lifestyle enabled by the environment of the orchard and/or its location, its physical features, landscape and climate, and its rural nature. Growing kiwifruit provided the flexibility and autonomy associated with self-employment.

They derived wellbeing from their work through the satisfaction they achieved from the financial return, production levels, comparison with others, achieving goals, providing for their family, 'growing', doing a 'good' job, producing a 'good' crop and using their skills.

Wellbeing was also associated with actually doing the work. Some found it to be a low stress occupation (though some thought the opposite). Many enjoyed what they saw as healthy physical work (though that could also be a negative). For some the switch to an oversight management role of several orchards has resulted in less physical work which has not always been a good thing. They felt it was great working in a pleasant 'outside' environment. For many it provided something 'active' to do in retirement.

An orchard was seen as a good place for bringing up children and later for family to visit. Owning an orchard enables planning the succession of land or the passing on of an inheritance to family members.

Neighbours can make a big impact on an orchard operation. It was important to participants whether these neighbours were family, organic or not organic, townies or lifestylers, good or bad, and what they grew (same or different, kiwifruit or not kiwifruit).

Orchards were seen to affect the financial wellbeing of a community. Money gained internationally flows out into local businesses and orchards provide employment for a wide range of people (and their families). Also, orchards impact on a community's environmental wellbeing through the use of sprays. For some, orchards are seen as green oases. Organic orchardists see themselves as 'havens' and examples to others of good environmental care. On the other hand, communities are seen as constraining what happens on orchards.

When the panels were compared, emphasis was given by:

- Green participants to retirement options, and the orchard as an investment for retirement.
- Organic participants to life on the orchard, caring for the environment, looking after the health of their own families and communities, and being a positive role model for others.
- Gold participants to the place outside the orchard, e.g., beaches, Bay of Plenty, land value of orchard, financial returns and high productivity.

8. What is managed well and what is hard to manage

The most common things that participants mentioned they were managing well were: labour, timing of labour, orchard management practices (e.g. pruning, pollination, fertilising, and spraying), managing the finances, the packout result and keeping "… a tidy orchard". Many also thought that they were managing their personal lives well.

Participants mentioned that they found it hard to find a balance in fruit size ("… not too big and not too small"), spraying ("Keeping it to a minimum but having healthy plants"), and between work, family and leisure. On the orchard they had difficulties with labour, in terms of its availability and in obtaining "quality work", getting the timing right, pruning and canopy management, *Armillaria*, maintaining and increasing production, size and quality, physical features of the landscape (soil, gullies, altitude) and making decisions about where to spend money.

Weather, in particular frosts, wind, rain and milder winters resulting in less winter chilling, was seen as hard to manage, unpredictable and changeable from year to year.

Some found that orchard management was made more difficult by the intrusion of the requirements of ZESPRI, GrowSafe, local council, compliance with BioGro, EUREP-GAP, OSH and ACC.

When the panels were compared:

- Gold participants were all confident that they were managing well (compared to six Green and three Organic).
- Organic participants gave an emphasis to concerns about *Armillaria*, weeds and weather. Five Organic participants had difficulty in answering the question. Most responded diffidently.
- Gold participants gave an emphasis to concerns about getting good DM in fruit.

9. Involvement in ARGOS

Participants frequently expressed great enthusiasm for ARGOS. They liked its principles, the long-term nature, the documentation of change and stories, and the questions it will raise. As one participant said, "I like involvement with ARGOS because I'm a nosey bugger …" Participants hoped that ARGOS would help them do a 'better' job of growing kiwifruit, managing the environment, making more money, and managing continuity into the future. It would do this by providing them with individual feedback and by giving them access to information they would not otherwise have that would help them learn and understand and enable them to make better decisions. They saw ARGOS as providing an opportunity to benchmark their performance and a way of reassuring them about their own orchard practices.

Most orchardists were quite altruistic in their expectations and hopes about who should benefit from the ARGOS programme. They felt that participation was good in itself, that it was a collaboration between the researcher and the researched and that sustainability is most important to the future and as such a good thing to research. They were open to whatever was found. They saw ARGOS as having the potential to be an advocate of kiwifruit growing.

The majority of participants did not express any concerns. They were pleased to participate. Some were aware that because of the long-term nature of ARGOS they might have to wait a while to get worthwhile results while others were less patient and wanted to see some benefits sooner rather than later.

The concerns that were expressed related to meeting OSH, EUREP-GAP and/or BioGro requirements, the time required and the paperwork that might be involved and fear that the findings will go against present orchard practices and lead to further restrictions on the autonomy of the orchardists and compliance issues.

7.0 Acknowledgments

The ARGOS project has been designed and implemented with the intention of providing quality information to both growers and their associated industries to ensure that they are broadly sustainable, internationally competitive and profitable. To facilitate this we greatly value the inputs provided by the participants and industry partners to enable us to undertake the research and ensure that our outputs are relevant.

To also assist us in this process we have an Oversight Committee which typically meets twice a year to review progress and provide suggestions on how we can enhance our overall performance. The members of the Kiwifruit Oversight Committee are:

- Dr David Steven (IPM Research Ltd)
- Alistair Mowat (ZESPRI Scientist)
- Jayson Benge (ARGOS Kiwifruit Field Manager)
- Jon Manhire (ARGOS Programme Manager)
- Ross Haycock (ARGOS Orchard Manager)
- Organic Grower Rep (replacement currently being sought)

ARGOS greatly appreciates the support and input from everyone above.

8.0 References and resources

Listed below are reports, research papers, ARGOS notes and other publications that have been produced by the ARGOS team on the ARGOS programme or aligned topics.

<u>ARGOS Reports</u>

AI2 - Transdisciplinary

AI 3 – Economic

Economics Rationale for ARGOS - Working Paper 3

AI 4 – Environmental

Environmental Research Rationale

AI 5 – Maori

Discussion paper
He Whenua Whakatipu Rationale for ARGOS - Working Paper 4
Scoping Report for monitoring and evaluation processes within ARGOS-Working Paper 5

AI 6 - On-farm Management

AI 6.1 Rationale for selection of Kiwifruit Orchards
AI 6.2 Rationale for selection of Sheep and Beef farms
AI 6.3 High Country Review and Plan
AI 6.4 Dairy Review and Plan
A1 6.5 Baseline report for Sheep/beef participants 2004
A1 6.6 Baseline report for Kiwifruit participants 2004
A1 6.7 Baseline report for High Country participants 2005
A1 6.8 Baseline report for Dairy participants 2005
A1 6.9 Sheep/beef Stakeholder Report 2005

A1 6.10 Kiwifruit Stakeholder Report 2005

AI 7 - Social

Social Dimensions of Sustainable Agriculture: a Rationale for Social Research in ARGOS - Working Paper 1

Social Research Compendium: Key Questions on Social Dimensions of Agricultural Sustainability - Working Paper 2

ARGOS Research Papers

Transdisciplinary

Economic

05/04 Food Markets, Trade Risks and Trends, by Caroline Saunders, Gareth Allison, Anita Wreford and Martin Emanuelsson, May 2005

Environmental

05/02 Soil quality on ARGOS kiwifruit orchards, 2004-2005, by Andrea Pearson, Jeff Reid , Jayson Benge and Henrik Moller, June 2005

05/03 Soil quality on ARGOS sheep & beef farms, 2004-2005, by Andrea Pearson, Jeff Reid, and Dave Lucock, June 2005

05/05 ARGOS biodiversity surveys on Kiwifruit Orchards and Sheep & beef farms in summer 2004-2005: rationale, focal taxa and methodology, by Grant Blackwell, Stephen Rate and Henrik Moller, June 2005

05/06 Bird community composition and relative abundance in production and natural habitats of New Zealand, by Grant Blackwell, Erin O'Neill, Francesca Buzzi, Dean Clarke, Tracey Dearlove, Marcia Green, Henrik Moller, Stephen Rate and Joanna Wright, June 2005

05/07 Interspecific interaction and habitat use by Australian magpies (Gymnorhina tibicen) on sheep and beef farms, South Island, New Zealand. Marcia Green, Erin O'Neil, Joanna Wright, Grant Blackwell and Henrik Moller, July 2005.

Maori

A draft farm-based sustainability monitoring system for Maori in the Ngai Tahu takiwa

On-farm Management

Social

05/01 Understanding Approaches to Kiwifruit Production in New Zealand : Report on First Qualitative Interviews of ARGOS Kiwifruit Participants, by Lesley Hunt, Chris Rosin, Carmen McLeod, Marion Read, John Fairweather and Hugh Campbell, June 2005.

ARGOS Research Notes

Research Note 1- Background to the ARGOS Programme June 2004
Research Note 2 –
Research Note 3 – ARGOS Transdisciplinary research
Research Note 4 - Cicadas in Kiwifruit Orchards
Research Note 5 – Market developments for NZ agricultural produce
Research Note 6 – Spiders in Kiwifruit Orchards
Research Note 7 – Organic Kiwifruit Survey
Research Note 8 - Analysis of ZESPRIs organic kiwifruit databases
Research Note 9 - Kiwifruit Orchardists

Research Note 10 - Kiwifruit Orchardists and their vision for the orchard
Research Note 11 - Sketch Map Results : Kiwifruit Sector
Research Note 12 - Sketch Map Results: Sheep/Beef Sector

ARGOS Newsletters

1. June 2004
2. January 2005
3. July 2005

ARGOnoteS

ARGOnoteS 1: Outline of BACI design, October 2003
ARGOnoteS 2: Some BACI design points, January 2004
ARGOnoteS 3: Threats to validity in BACI design, February 2004
ARGOnoteS 4: Matching Social and Economic variables in BACI design, February 2004
ARGOnoteS 5: BACI postponed, March 2004
ARGOnoteS 6: Panels, not Cohorts, January 2005
ARGOnoteS 7: Causation and BACI, February 2004
ARGOnoteS 8: Broadening Research Focus and strengthening ethical safeguards in ARGOS, April 2004
ARGOnoteS 9: Towards Transdisciplinary Research within ARGOS: an ecologist's suggestions for process and research priority setting, July 2004
ARGOnoteS 10: Monitoring the relative abundance of lizards in AROGS kiwifruit orchards
ARGOnoteS 11: Kiwifruit Property reports, June 2005
ARGOnoteS 12:
ARGOnoteS 13: Qualitative research methodology, July 2005

Aligned Research Reports and Papers

Transdisciplinary

Economic

Saunders, C.M. (2005): Implications of changed EU agricultural polices for Australian and New Zealand farmers. Farm Policy Journal 2(2) pp23-31.

Saunders, C.M. (2004): The Implications for NZ Trade of Change in EU Agricultural Policy, in Particular the Development of Agri-environmental Policy in New Zealand and Europe: Connections and Comparisons Editor(s) of Book: Bernadette Luciano & David Mayes Rodopi, Netherlands.

Saunders, C.M. and Cagatay, S. (2004): Trade and the environment: economic and environmental impacts of global dairy trade liberalization. Journal of Environmental Assessment Policy and Management Vol 6 (3) pp 1-27.

Saunders, C.M. and Kaye Blake, B. (2003): Economic impacts on NZ of GM crops: Results from partial equilibrium modelling. NZ Biotechnology Association Journal 58 pp 69-80.

Saunders, C.M. (2003): Changes in EU Agricultural Policy and their potential impacts on Australia, New Zealand and Japanese Dairy Sectors. Asia-Pacific Journal of EU Studies (1) 2 pp 161-177.

Saunders, C. and Cagatay S., (2003): Commercial Release of GM Food Products in New Zealand: Using a Partial Equilibrium Trade Model to Assess the Impact on Producer Returns in NZ, *Australian Journal of Agricultural and Resource Economics 47(2).*

Saunders, C and Emanuelsson M. (2005): Modelling the implications for NZ trade and producer returns from different scenarios relating to the demand and supply of organic products.

Environmental
Intensification of New Zealand agriculture since 1960 and its implications for biodiversity conservation, by Catriona MacLeod and Henrik Moller.

A System View of Farming in New Zealand: Multiple Functions lead to Multiple Benefits, by Chris J. K. Perley, University of Otago.

Maori
Indigenous Knowledge is not a construct – The challenge of incorporating indigenous knowledge into multidisciplinary discussion, by John Reid.

On-farm Management

Social
An Analysis of Zespri's 2003 Organic Kiwifruit Database: Factors Affecting Production, by Lesley Hunt and John Fairweather, AERU, Lincoln University 2004

Results from a Survey of Organic Kiwifruit Growers: Problems and Practices that affect Production, by Andrew Cook, Lesley Hunt and John Fairweather, AERU, Lincoln University 2004.

Cook A. J. and Fairweather J. R. (2004), Farmer and Grower Intentions to Use Gene Technology: Results from a Resurvey. AgBioForum 6 (3): 120-127. http://www.agbioforum.missouri.edu

EUREP-GAP, Agri-Food System Governance and Organic Food Exports from New Zealand, by Hugh Campbell, Carmen McLeod and Chris Rosin.

Auditing sustainability: the impact of EurepGAP on organic farming in New Zealand, Hugh Campbell, Carmen McLeod & Chris Rosin.

Audit Cultures and the Antipodes: the Implications of EUREP-GAP for New Zealand and Australian Agri-food Industries. Hugh Campbell, The University of Otago, New Zealand, Geoffrey Lawrence and Kiah Smith, The University of Queensland, Australia. Chapter submitted to Murdoch. J. and Marsden, T. (eds.) Between the local and the global: An institutional perspective on food. Elsevier. (forthcoming – 2006).

Disciplining the Organic Commodity, By Hugh Campbell and Annie Stuart. Chapter in Higgins, V. and Lawrence, G. (eds.) Agricultural Governance: Globalization and the New Politics of Regulation, London: Routledge (forthcoming 2005).

Green Protectionism Part 2: EUREP-GAP, Agri-Food Systems Governance and the Decline of Organic Exporting from New Zealand, Assoc Prof Hugh Campbell, University of Otago.

Appendix 1. Examples of freshwater fish found on ARGOS orchards (Source: Website for the New Zealand Native Fresh Water Fish Society http://www.nzfreshwater.org/)

BANDED KÖKOPU (Galaxiidae: Galaxias fasciatus)

The banded kökopu is a smooth-skinned, largely nocturnal fish that may reside in urban areas where habitat is suitable and they are not often disturbed; often surprisingly close to houses. These fish are only found in New Zealand, living within small tributaries, in slow moving pools. This is usually in native bush where there is sufficient overhead forest cover. They are found throughout New Zealand, but are more common near the coast, and being absent from deforested landscape e.g. intensive agricultural areas such as the Waikato and Manawatu. Their food largely consists of terrestrial insects such as beetles and spiders falling onto the waters surface, where their vibrations caused by their struggles are then detected. They can grow to around 280 mm long, with fish living to more than 10 years old.

INANGA (Galaxiidae: Galaxias maculatus)

By far the most common species found in the spring whitebait run migrating up from the sea, inanga are approximately 10 cm long, and are most commonly found in wetlands, streams, rivers, and lakes with easy access to the nearby sea. As they are fairly tolerant of salt water, they are sometimes also found in tidal estuaries. They prefer slower flowing waters, at the surface of which they may be found hunting at night for terrestrial insects falling on the surface, for aquatic insects, and for zooplankton crustaceans. They have very wide feeding habitats even being known to thrive on cheese in captivity! Inanga rarely live for more than 2 years, usually having migrated and spawned in a lower estuary at the end of their first year.

NORTHERN KOURA (Parastacidae: Paranephrops planifrons)

New Zealand has two freshwater crayfish species, with this species being found throughout the North Island and in Northern and West Coast of the South Island. They are slightly smaller (up to 70 mm long in streams) and also less robust and hairy than their Southern cousins. Lengths of crayfish are greatest in lakes (to around 160 mm), with ages over 3 years not being uncommon. They are largely nocturnal in their habitat of lakes, streams, and wetlands, where they feed opportunistically on aquatic insects and vegetation. Freshwater crayfish are thought to function as a keystone species, with the modifications they make upon the environment permitting as greater range of species to exist than if they were not present. These crustaceans also provide an important food source for larger fish and waterfowl. All koura are non-migratory, and carry their eggs and then their developing young under their tails. Juveniles are released as perfect miniatures of the adult, able to fend for themselves immediately.

FRESHWATER SHRIMP (Atyidae: Paratya curvirostris)

New Zealand has only a single species of decapod freshwater shrimp, Paratya curvirostris. This species is a typical occupant of lowland streams, where it is usually found amongst vegetation. New Zealand's freshwater shrimp is the only member of its family to exhibit protandry; a remarkable life history in which sex is defined by the age and maturity of the individual rather than at development. All individuals undergo a male phase of development before transforming to adult female forms. Native freshwater shrimp are detritivores feeding on detritus, algal films on rocks, and wood etc., and on bacteria in decreasing order of importance. These are scraped off and picked up by the 2 pairs of pincers held out front which possess large curved hairs.

Shortfin eel (Anguilla australis)

Photo courtesy of the website for Landcare Research NZ (http://www.landcareresearch.co.nz/)

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