**A project facilitated by the Research and Development Group of the Bio Dynamic Farming and Gardening Association**

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**A REPORT AND CATALOGUE PREPARED WITH FUNDING FROM THE MINISTRY FOR THE ENVIRONMENT'S SUSTAINABLE MANAGEMENT FUND (NO. 2191), DEXCEL AND THE TINDALL FOUNDATION**


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# REPORT UPDATE AUGUST 2004

This is the final update of the report.

All contact details and websites have been checked and revised in:

The List of Useful Sites at the end of Chapter 6 (pp. 111 – 113)

Chapters 9 and 10 (pp.143 – 173)

## Development of Producer oriented Site-specific research.

Several overseas research institutions that undertake organic farming research have been developing new research methodologies, working with producers to improve farming practices. Institutes such as the Louis Bolk Institute (LBI) and the Swiss Organic Research Institute (FIBL) are a driving force behind the adoption of organic and biodynamic technology by producers. They consider that good organic biodynamic research involves the producers.

The specific knowledge and skill base available for organic and biodynamic production has increased significantly so that there is less risk for newcomers. Methodology includes the development of observational and intuitive skills; skills, which farmers have been using for a long time but which tend to be neglected by modern science. These methods could readily be transferred to New Zealand.

Basic organic farming starts with the soil (healthy soil provides for healthy plants and healthy animals). Nevertheless, the first question many producers ask is what they can do about specific pest and diseases. Conventional science generally responds with research into the specific pest or diseases. But there may be a better way.

Black spot in apple orchards and botrytis in vineyards are examples of specific problems. Research usually concentrates on the lifecycle of the pest to determine where it can be interrupted. This has resulted in more environmentally friendly treatments such as fewer and less-disrupting sprays (for example, sulphur and copper based spays) or the use of antagonistic micro-organisms. It gives us more useable knowledge, but it is not the complete answer to our question, “What are all the factors involved with the occurrence of black spot or botrytis?” The occurrence of both diseases is varietal and site specific, which means that factors falling under those two headings need to be addressed.

A factor generally overlooked outside the organic research centres is soil/nutrient dynamics. Unbalanced nutrition is generally the main contributing factor to plant pest and diseases; one obvious factor is excessive nitrogen in spring and summer. It encourages both black spot in orchards and botrytis in vineyards. Most newcomers would say, “We do not use fertiliser so how do we have excessive nitrogen?” This is a suitable research question for on-farm research, because it is very site-specific.

Nitrogen comes from soil organic matter mineralised by soil micro-organisms. Thus the amount of soil organic matter determines the potential amount of nitrogen that could be released. It also means that the right conditions in the soil to maintain suitable micro-organisms are needed, and this is where the problem often lies. The micro-organism requires moisture, air, warmth, food, a certain pH etc, to be functionally active, and a change in the weather can cause a drop or an increase in activity within a few hours. Micro-organisms are also very susceptible to daily and seasonal rhythms. The use of external inputs can cause a temporary population shift and the use of harsh agro-chemical creates nearly lifeless soils. This means that every different management method has different effects on microbial activity. If we include the factors such as different soil type, different (micro) climates, and different crop requirements (for example, nitrogen demand in apples is higher than in grapes) you will easily see that nitrogen management is a site-specific challenge.

Let's go further into the detail. Let's say our soil has an organic matter content of 3% which would mean about 6000 kg of nitrogen per hectare. We know that in a healthy soil in temperate regions we will probably have 2-4% mineralisation per year. This means 120 to 220 kg of nitrogen per year can be available for crop growth. For the needs of olives or grapes, 220 kg would be on the high side and a warm, moist spring could result in higher peacock spot (in olives) and higher botrytis (in grapes). Apples would still be outside the risk zone since their demand for nitrogen is higher. In a situation with 5% soil organic matter however, which would lead to 200 - 400 kg/ha available nitrogen, there would also be a risk of increased black spot. This is a theoretical example but it shows the importance of holistic organic / biodynamic research, which is aimed at site-specific prevention rather than cure.

Research stations like LBI and others mentioned in the report investigate nutrient dynamics (mineralisation, immobilisation, etc) on the farm and how they can be influenced to the grower's benefit. We cannot just work with a rough estimate of 2-4 % mineralisation / year in a temperate climate. To make nutrient studies really useful we need clearer rates of mineralisation, not yet available for many regions in NZ.

This illustrates how to focus formal research on questions of practical importance and make more effective use of the scarce time and expertise of producers and scientists Benefits of such on-farm research for the producer and the trained researcher include[1]:

- *The scientist can acquire deeper insights into problems (and potential solutions) from the producer's point of view and discover possibilities not previously contemplated. These can be investigated in jointly designed and managed trials.*
- *Producers often have intuitive methods of problem solving, that the researcher can work with to develop into more transparent and scientifically acceptable methods.*
- *Criteria for content, design and evaluation of scientific trials can be adjusted to ensure that the producers' priorities are met while still satisfying accepted research criteria.*
- *Both parties can increase their understanding of local agro-ecological and socio-economic conditions and how introduced technologies can be adapted to them.*
- All participants may be able to identify details to be studied more rigorously.

[1]Adopted from Farmers' Research in Practice; lessons from the field, 1997, edited by Laurens van Veldhuizen,Ann Waters-Bayer, Ricardo Ramirez, Debra A. Johnson and John Thompson)

# REPORT UPDATE AUGUST 2003

## INTRODUCTION

This updated version of the report contains the following changes:

- Errors and omissions pointed out to us have been corrected – and a list of corrections is included;
- All web site references have been checked and updated where necessary and some new sites have been included in chapter 9;
- Databases (CAB Abstracts, Biological Abstracts) have been searched for the latest relevant research reports in the areas of pasture, dairy and general organic soil management and a new chapter containing this material has been included.

There is an increasing volume of research reports available on the internet. Most research institutes give resumes of current research projects and lists of publications. The New Zealand research institutes Landcare, www.landcareresearch.co.nz , AgResearch, www.agresearch.cri.nz , Dexcel, www.dexcel.co.nz and Hort Research, www.hortresearch.co.nz websites contain useful research reports. International sites, listed in chapter 9 of this report, have been updated. Sites which provide several practical and relevant downloadable publications include US Appropriate Technology Transfer for Rural Area (ATTRA) **http://attra.ncat.org**, the Organic Centre, Wales, www.aber.ac.uk, the Institute for Biodynamic Research, Germany, www.ibdf.de, Louis Bolk Institute, Netherlands www.louisbolk.nl , and the Swiss Research Institute of Organic Agriculture (FiBL) www.fibl.org . Most scientific journals now have on-line versions, available by subscription or through University libraries. The CAB organic farming abstracts database can be accessed at www.organic-research.com. Search engines, such as www.google.co.nz also make accessing research on any topic easy.

Practical guidance for farmers on improving farm sustainability is more accessible eg from regional councils. Guides for organic management of orchards and pastures have recently been produced by the Soil and Health Association and Biodynamic Farming and Gardening Association (2003)

Many scientists are focussing on how to mitigate environmental impacts of farming, such as by reducing greenhouse gas emissions and damage to soil structure. Results from this research are relevant to organic and conventional producers.

Research into soil biological processes and how they provide plant nutrients is ongoing. There is also new research on soil health and fertility indicators. Such indicators can be used by organic farmers and growers to supplement traditional sensory and lab testing assessment. Research that seeks greater understanding of soil organisms is also useful, particularly research on organisms that form close relationships with plant roots such as nodule forming bacteria and arbuscular mycorhizal (AM) fungi is relevant to organic producers. Soil biology tests are now available in New Zealand.

Biological farming, in which soils are minerally balanced according to the Albrecht/Reams theorem, to foster soil life and increase quantity and quality of plant nutrient contents, is being developed in USA and Australia (eg Zimmer, 2000). Further research is needed on this approach, and also on effects of the various commercial organic products such as humus, seaweed, and vermicast.

Several recent organic, biodynamic and conventional system comparison studies are reported in this review, and also other recent research relevant to organic pasture and orchard soil management.

## List of corrections to original text

**P 89** – under Frequency of applications

Bisterbosch

>Should read "found in her research on lettuce, which included extensive phenomenological observations, that application of preparations 500 and 501 more than once during the growth season positively affected product quality. She concluded that the plants were more healthy.

**Chapter 8**

**Page 132**

Paragraph 6, line 4 …"elicitors" respond to the location….

**Chapter 10,**

**Page 164**

The information about **The Soil and Health Association** was written by Brendan Hoare (see Page 184) not by Peter Bacchus.

**Page 168** Under **Bio Dynamic Farming and Gardening Association**

The regional group contacts for the following areas are now:

Northland - Karen Gregory, Ph. 09 431 4386

Bay of Plenty – West - Peter Bacchus and Gill Cole, Ph. 07 542 1914

Manawatu - Joanne and Greg Turner, Ph. 06 329 0943

Canterbury - Peter White, Ph. 03 314 6886

On page 169 the email address of the Bio Dynamic Farming and Gardening

**National Office is now:** info@biodynamic.org.nz

# UPDATE - SOIL MANAGEMENT IN ORGANIC SYSTEMS

## Maintaining soil fertility – Fallowing and Composting

Organic systems rely mainly on nutrient cycling by soil organisms. In a good soil with an active food web, nutrients are continually made available as the plant grows; an organic farmer feeds pasture, trees and other crops indirectly by feeding the soil organisms. Fallowing to build up soil organic matter and the microbial biomass is an important management practise that has been researched in New Zealand, for example by Nie *et al.* (1997).

Investigation of effects of different organic amendments on the microbial biomass and enzyme activity increases understanding of the organic matter decomposition processes. In a 5-year field experiment in Spain comparing municipal solid waste (MSW) compost, sheep manure, vermicompost, humic acid solution and anaerobically-digested sewage sludge amendments, the MSW compost had the greatest effect on the microbial biomass content and selected enzymatic activities (Albiach *et al.*, 2000). No significant effects of the recommended low application rates of vermicompost and humic acid solution were found, suggesting that organic residues had the greatest effect on the enzymes measured.

Several guides to making and using compost are available on the internet. For example, the ATTRA website http://attra.ncat.org provides a Farm-scale composting resource list. The Woods End Research Laboratory, USA www.woodsend.org provides a compost test interpretation guideline and publications downloadable in pdf form such as "The art and science of composting" by Cooperband (2002). Publications with useful research reports on composting including by Heeres *et al.* (2001) and Raupp, (2002) are also listed on this website.

### Development of soil quality indicators

Conventional soil mineral analysis is helpful in indicating whether there are major deficiencies and imbalances in soil minerals, but generally only shows what elements are present in inorganic form in the depth of soil sampled at the particular time at which the soil test was taken. In contrast to these conventional tests, tests which show soil structure and how well the food web is working developed by Landcare, Lincoln University and overseas provide useful information for organic farmers. The SINDI Soil quality indicators, a web-based tool available on the Landcare website, www.landcare.cri.nz, provides a guide to soil fertility and potential problems for any area of New Zealand.

Sparling *et al.* (1998) discussed how the carbon quotient,

$$\frac{\text{total weight of microbial carbon (C)}}{\text{total C}}$$

can give an indication of soil health. For a silty clay loam at Kairanga, he determined this quotient at 2.97, but it fell to 1.5 under maize cropping, indicating a decrease in soil health. Goh *et al.* (1999) found that microbial biomass C and its ratio with total C and the ratio of hot-water extractable C to hot-water extractable carbohydrate were sensitive indicators capable of distinguishing significant differences between different orchard management systems.

Parameters shown by earlier research by Reganold *et al.* (1993) to be significantly different between paired conventional and biodynamic farms were soil bulk density, organic matter content, soil respiration, mineralisable nitrogen and the ratio of mineralisable nitrogen to organic carbon. Regular measurement of physical parameters of soil health such as soil bulk density enables monitoring effects of management on sustainability. Mata *et al.* (2002) discuss soil health assessment during conversion to organic farming.

The long-term DOC trial, that has been comparing organic, biodynamic and two conventional treatments in a cropping/pasture rotational system since 1978 in Switzerland, has provided considerable useful research results. Soil aggregate stability was found to be 10 to 60% higher in the organic than in the mineral plots and there were positive correlations between aggregate stability and microbial and earthworm biomass (Maeder *et al.*, 2002). In soil samples from the same DOC trial, the quantity of carbon (C) and nitrogen (N) in the microbial biomass was highest and the ratio of microbial C:N lowest for the biodynamic treatment, indicating enhanced decomposition of soil organic matter (Fliessbach and Maeder, 2000). Carbon utilization of plant material added to soil was traced by radioactive carbon (14C) labelling for of soil from the different treatments in the same trial (Maeder *et al.,* 2002). Under controlled conditions, the more diverse microbial community of the biodynamic soil decomposed more 14C-labeled plant material than that of the conventional soils, and in the field, undecomposed plant material decayed more completely in the organic systems. Maeder *et al.* concluded that microbial communities with an increased diversity in organic soils transform carbon from organic debris into biomass at lower energy costs, building up a higher microbial biomass.

Gunapala and Scow (1998) found an increase in the proportion of total C in the microbial biomass under an organic system compared to soil in a conventional system. They considered that although a higher proportion of nutrients in the microbial biomass can reduce N availability in conventional systems, under the organic system it contributed to an increased N availability for plant uptake.

Characterisation of the various forms of non-microbial carbon can also provide an indication of soil fertility. Some would be in partially decomposed plant and animal material but most is in relatively stable humic compounds. Fliessbach and Maeder (2000) fractionated soil organic matter according to size density. They found that the light fraction (mainly fresh organic material) of the organic matter was decomposed more quickly in organic systems, and that the ratio of microbial biomass to light fraction material could be used as an indicator of the quality of recently added organic material. There were also differences in carbon (C):nitrogen (N) ratios for different density fractions of the soil organic matter. Raupp and Oltmanns (2002) provided further discussion of this research. Gunapala and Scow (1998) found significantly lower C:N for organic compared to conventionally managed soil and concluded that this is indicative of a habitat where bacteria may be more important and fungi less dominant in organic systems.

## Nutrient mineralisation

Further research on nitrogen and other nutrient mineralisation has been compiled into practical guides for farmers and growers. Some useful guides include “A guide to nitrogen management for field vegetables by Tremblay *et al.* (2001), Soil organic matter budgeting in sustainable farming by Koopmans and Goldstein, (1999), Sustainable soil management by Sullivan, (2001), Nitrogen mineralisation in organic farming systems by Koopmans *et al,.* (2001), Understanding soil nitrogen supply:organic matter quality and quantity by Hatch *et al.*, (2002)" These are all listed and/or downloadable on websites as detailed in the reference section below.

Soil organisms such as protozoa and nematodes, which feed on microorganisms but require less nitrogen than is contained in most bacteria, provide a continual release of nitrogenous substances available for plant uptake, in addition to that released by decay of the soil microorganisms (Ingham, 1998). She showed how nematodes increase N availability and plant growth rate by 25 – 75% above that obtained when only bacteria are present in the soil. Net N immobilization is more likely if the soil is fungal rather than bacteria dominated. Chen and Ferris (1999) measured nitrogen mineralization in columns of sand containing various combinations of fungi and fungal-feeding nematodes, and found low levels of mineralized N in columns with fungi alone, particularly at high C:N, but higher N mineralization when nematodes were included.

Other larger soil organisms are also important in releasing nutrients from soil organic matter. In the long-term European DOC trial, biomass and abundance of earthworms were higher by a factor of 1.3 to 3.2 in the organic compared to mineral plots (Maeder *et al.* 2002) Average activity density of carabids, staphylinids, and spiders, which they consider sensitive indicators of soil fertility, was almost twice as high in the organic compared to mineral plots.

The importance of amino acid metabolism in the soil in relation to uptake of amino acids by plant roots and the availability of phosphorus is discussed by Scheller (2000). As for nitrogen supply it is difficult to assess potential phosphorus (P) availability under an organic system, as it depends on soil phosphatase activity from microbial activity and plant exudates and on uptake through AM fungi. The biomass may contains 2-5% of the total organic P in arable soil and 20% or more in some grassland and forest soils, and the quantity of P mineralised or immobilised depends on the C:P ratio (Mullen, 1998). He estimated that the C:P ratio should be less than 200:1 for net mineralisation and availability of phosphorus for plant uptake. The quality of humus affects phosphorus availability (Sarapatka, 2000). He found that the ratio of 2 main constituents, humic acid:fulvic acid, was negatively correlated with phosphorus availability, probably because smaller molecular weight molecules would be more easily decomposed by phosphatase enzymes.

Arbuscular mycorrhizal (AM) fungi are particularly important for P supply in organic systems, as they can contribute up to 80% of plant P uptake (Li *et al.*. 1991). Bolan (1991) reviewed their role in the uptake of P. Clark and Zeto (2000) tested the effects of AM fungi on enhancing or reducing acquisition of nutrients in plants. The nutrients enhanced most in host plants grown in many soils of high and low soil pH were found to be P, N, zinc, and copper, but potassium, calcium and magnesium are enhanced when plants are grown in acidic soils. Many AM fungi were also found to have the ability to ameliorate aluminium and manganese toxicities for plants grown in acidic soil. Suzuki *et al.* (2001) showed that AM fungi increased uptake of sodium, zinc and selenium, but not some other elements including iron and cobalt. Bagyaraj (1984) discusses interactions between AM fungi and other organisms. The presence of AM fungi has been found to increase nitrogen fixation by both nodular and free-living N-fixing bacteria. This was found to be not only through accessing of more P, but also through provision of more carbon, trace elements and plant hormones to the bacteria. Soil aggregate stability, drought stress tolerance and nutrient availability have also been found to be positively related to AM fungi colonisation (Tarafdar and Rao, 2002).

Methods to determine soil sulphur mineralisation and availability have been researched in New Zealand by Pamidi *et al.* (2001). Potassium (K) supply is also important for organic systems on New Zealand soils. Supply under different conditions in New Zealand was reviewed by Kirkman *et al*. (1994). Supply of K in New Zealand Pallic soils (yellow-grey earths in rolling and hilly areas of the east coast of the south island and in Hawkes Bay, Wairarapa and Manawatu) was studied by Surapaneni *et al*. (2002). They concluded that the ability of these soils to supply K is related directly to the amounts of mica present in the clay fraction. However good K supplying soils are transformed to K depleted soils as a result of increased weathering and leaching and removal of K by intensive farming systems. Surapaneni *et al* recommended that the Knex (acid-extractable K) test be used to show variations in plant available K status of the soils.

**Soil mineral balancing and biological farming**

In USA and Australia biological farming methods are being developed. Biological farming is an organic system that also incorporates soil mineral balancing, based on recommendations developed from Albrecht (1975). Albrecht recommended cation balancing for optimum soil fertility and crop and animal health, using a formula of base saturation ratios of about 65-75% calcium (Ca), 10-15% magnesium (Mg), 2-5% potassium (K), 0.5-3% sodium (Na), 3% aluminium (Al) and 10-15% hydrogen (H). For sandy soils with low cation exchange capacity, the formula is modified slightly, to about 60% Ca, 20% Mg and 6-8% K. The US Brookside laboratory works with this concept. Several books describing this system have come on the market recently including by Zimmer (2000) and Scow and Walters (1995).

Albrecht (1975) studied links between low pasture magnesium content and grass staggers in relation to soil balance of calcium, magnesium and potassium. He found that when there is high availability of potassium in the soil, the potassium is taken up at the expense of calcium and magnesium, resulting in low pasture content of calcium and magnesium and reduced clover growth. High nitrogen application has a similar effect of reducing calcium and magnesium uptake. This imbalance is believed to "tighten" the soil and degrade crumb structure, hamper aeration and drainage, cause surface crusting and hardpans, inhibit beneficial soil organisms and humus formation, aggravate weed, pest and disease problems, and hurt crop and livestock health. Applications of high calcium lime or gypsum to restore the balance are claimed to enhance soil biological activity and organic matter levels; to increase availability of phosphorus, sulphur and other nutrients; and to improve produce flavour, nutritional value and shelf life of products. However, Ingham (2002) asserts that single dressings over about 500kg/ha can cause short term dehydration damage to soil organisms.

Recent research into the effects of applying the nutrient balancing concept on vegetable production on organic farms was described by Schonbeck, (2000). He found that high calcium (Ca) treatment had no detectable effect on soil organic matter, biological activity, crop uptake of N, P and micronutrients, abundance of weeds, incidence of disease or insect pest damage, or Brix level in broccoli or tomato for the soils studied. Broccoli yielded about 11% more in the high Ca treatment, whereas treatment effects on tomato and squash yield were inconsistent. Soil bulk density, moisture content, and water infiltration rate were improved in some soils but not in most of them. Often, growers can remedy cation balance by reducing inputs (e.g. excess potassium), and may not need Ca amendments if soil and crops are already healthy. He recommended a shift in focus toward developing a holistic, site-specific and resource-conserving approach. Soil nutrient balancing can therefore be used as a guide rather than a rigid formula, taking into account all nutrients, including sulphur and trace elements that are often lacking in New Zealand soils.

**Nutrient budgets**

A review of 88 organic farm nutrient budgets in nine temperate countries concluded that nutrient budgets are a useful tool for maintaining a balance between nutrient inputs and outputs and long-term sustainability of organic systems (Watson *et al.*, 2002). The data illustrate the diversity of management systems in place on organic farms but also that nutrient budgets are unable to provide good estimates of N fixation and quantities of nutrients in purchased manures. Nitrogen budgets showed an N surplus (average 83.2 kg N ha/ year). The efficiency of N use, defined as outputs/inputs, was highest (0.9) and lowest (0.2) in arable and beef systems, respectively. The phosphorus (P) and potassium (K) budgets showed both surpluses and deficits, with horticultural systems showing large surpluses resulting from purchased manure.

Some results pertinent to the question as to whether organic systems can maintain soil phosphorus long-term are provided by Tagmann *et al.* (2001) from analyses of the different treatments in the long-term DOK trial in Switzerland. Over 21 years, the average P input by fertilizers was lower than P output by harvested products in all treatments but one with soluble fertilisers. The resulting average P balances (input minus output) were: control, -21; biodynamic, -8; organic, -6; conventional fertilisers –5 and +4 kg P/ha per year. In addition, over 21 years, an average between 5.5 and 10.9 kg P/ha per year was lost from topsoil of fertilized treatments. In the same time, P contents in the subsoil increased between 7.0 and 8.7 kg P/ha per year. Budgets from organic and conventional farming were also compared in an 11 years trial on a grassland farm in Austria (Gruber *et al.*, 2001). P input and output was well balanced but negative balances were found for K, reflected in decreasing K concentrations in the soil.

Phosphorus levels decreased and potassium (ammonium-acetate lactate extractable) increased or were stable over 13 years on 5 organic sandy-loam dairy farms in Norway (Loes, 2000) Acid soluble K decreased significantly on one farm. An earlier report by Oberson *et al.* (1993) discussed the high P content in and mineralisation by the microbial biomass in organically farmed soils, which could explain the net gain in P recorded. However, such long-term net gains would be less likely to be found in New Zealand soils low in P and often with high P retention. Further research on New Zealand soils is needed on this question. Nutrient budgeting for trace elements is discussed by Owens and Watson (2002).

**Farm and orchard conversion to organics and system comparison studies**

A comprehensive New Zealand report investigates the challenges associated with shifting from a conventional to organic system and conversion planning (Mackay *et al.*, 2000). Fairweather and Campbell (2001) have published a review of research on the consequences of converting to organic production.

Several studies comparing organic and conventional farms were reported in the last two years. Long-term effects of organically and conventionally cultivated systems on physical, chemical and biological characteristics of 7 sandy-loam dairy-farm soils in Denmark were studied by Schjonning *et al.* (2002). All organically managed soils were dairy farm soils. Irrespective of agricultural system, the use of tractors and heavy machinery had caused compaction of the subsoil in the form of a dense pan below ploughing depth. Results highlight the effects of soil tillage and traffic in agriculture and confirm the positive effects of organic manures and diversified crop rotations on soil quality aspects, such as microbial biomass. The different biotic mechanisms responsible for macro-aggregation varied from soil to soil. Results of the long-term Swiss DOK trial are reported by Alfoldi *et al.* (2002) and are also available on the Swiss FIBL Research Institute website, www.fibl.org., addressing questions such as "Is organic farming beneficial to soils?

A study of apple production systems in the USA by Andrews *et al.* (2001) compared integrated, organic, and conventional apple production systems on horticultural performance, soil quality, and orchard profitability. Planted in 1994, all three systems were not profitable until 1999. In comparison to the conventional system, higher production costs for the integrated and organic systems in 1994 and organic system in 1995 were largely due to differences in weed control practices. Fruit yield was slightly higher in the organic treatment in 1997 and 1998 than yields in the integrated and conventional treatments, which were similar. Higher fruit densities per tree and typically drier soils in the organic treatment may be responsible for the smaller organic fruit. The organic fruit was significantly smaller but generally as firm or firmer than fruit from the other systems and had lower nitrogen content. Assessment of soil quality in 1998 and 1999 indicated that the integrated and organic production systems maintained higher soil quality than did the conventional system.

An investigation of effects of biodynamic compost and field spray preparations on the soil biological community by Carpenter-Boggs *et al.* (2000) found that organic management enhanced soil biological activity but there was no significant difference between biodynamic and non-biodynamic composts. Both increased soil microbial biomass, respiration, dehydrogenase activity, soil C mineralized in 10 d (MinC), earthworm (Lumbricus terrestris) population and biomass, and metabolic quotient of respiration per unit biomass (qCO2) by the second year of study. Use of biodynamic field sprays was associated with more MinC and minor differences in soil microbial fatty acid profiles in the first year of study. The inconsistent results of various trials on effects of the biodynamic preparations likely reflect subtle, different effects at different times, with different quality preparations and in different conditions, which make it hard to record consistent, large enough differences to be statistically significant.

## DAIRY PASTURE MANAGEMENT

### Soil type and pasture quality

Analysis of forage quality on ten organic dairy farms in the Netherlands on different soil types showed that forage quality was better with high clover cover (Pinxterhuis, 2002). Mineral levels and trace elements in forage were higher when the cover of good grasses and clover was higher and were not related to the cover of herbs. Good grasses (*Lolium perenne*) persisted well on sandy soils. Burgt *et al.* (2001) and Baars (2001), discuss effects of animal manures on grassland.

### Environmental improvement and reducing adverse environmental effects

Research of several sustainability questions such as application of dairy shed effluent to pastures, effects of machinery compaction and cow pugging and benefits from trees, is relevant to both conventional and organic farming systems. Some recent research is reviewed below.

### Trees on dairy farms

Many farmers are planting more trees for shelter, shade and for their browse value. A recent New Zealand study of the value of poplar and willow forage by Kemp *et al.* (2001) found that the edible forage dry matter (DM) of 5-10 year old trees ranged from 2 to 22 kg DM/tree. The nutritive values of poplars and willows were found to be similar, but the concentration of condensed tannins was usually higher in willows. Tannins improve ruminants' digestion, thus helping to maintain good health

### Pugging

A single, severe pugging event in early spring on pasture production, clover growth, and nitrogen fixation on dairy pasture in the Waikato was found to decrease clover production by up to 65% and grass by 38% (Menneer *et al.*, 2001). Nitrogenase activity of soil microorganisms decreased by up to 90% within 3 days of pugging. After 10 years, moderate or severe pugging was predicted to decrease N fixation, soil organic N and grass growth, and result in a loss in milk production by 21 and 54%, respectively. A model that predicts the effect of treading on pasture damage and its subsequent recovery under various soil water and stocking conditions on hill country has been developed by Finlayson *et al.* (2002). The model provides a decision-support tool for assisting grazing management during periods when pastures are sensitive to damage.

### Dairy shed effluent

There has been considerable research focus on the effects of applying dairy shed effluent to pasture. One study by Zaman *et al.* (2002) found increased enzyme activities and microbial biomass in the soil compared to soil treated with chemical fertilizers. However, the effluent can have adverse effects. It can increase soil populations of *Pythium* species which are pathogenic on clover and ryegrass roots (Waipara and Hawkins, 2000). Spreading effluent can also result in bacterial contamination of shallow groundwater and/or waterways (Aislabie *et al.*, 2001). This was found to occur more readily in poorly drained gley soils compared to allophanic and pumice soils. Further research of effects on gley soils found that nitrogen leaching was reduced by drainage that lowered the water table level (Singleton *et al.*, 2001)

## Greenhouse gas emission

There has been considerable research started recently on factors that affect the quantity of greenhouse gases emitted by grazing animals. For example, research by DEXCEL (Woodward, 2003), showed that feeding high quality legume forages to dairy cows can reduce methane production per unit production compared with cows fed poorer quality, high fibre pasture diets. Nitrous oxide emissions by New Zealand livestock come mainly from dung and urine excreted on grazed pastures, and vary according to soil drainage capability (Klein *et al.*, 2002). Research comparing emissions on conventional and organic farms in New Zealand is needed as it is possible that increased soil organism activity that increases rate of excreta breakdown and incorporation into the soil would reduce nitrous oxide emissions. In addition, the quality of the excreta could be different from consumption of different pasture.

The question of whether organic management affects emissions was reviewed in Europe by Boer, (2003). A pilot study comparing conventional and organic milk production found that acidification potential of milk production was not necessarily reduced by changing from conventional to organic milk production. Water eutrophication potential per t of milk or per ha of farmland was lower for organic than for conventional milk production due to lower fertilizer application rates. It was clear that different case studies cannot be compared directly and that in-depth research is needed to understand underlying processes, and to predict, or measure, variation in emissions realized in practice. The study also reported that organic milk production inherently increased methane emission. However, this assertion is less likely to apply to New Zealand conditions where cattle in all systems are mainly pasture fed. It is possible that organic systems are producing higher quality pasture containing more legumes, which would result in less methane emission according to the DEXCEL research reported above.

## ORCHARD SOIL MANAGEMENT

Nitrogen supply

There has been more research aimed at assisting organic farmers and growers to manage nitrogen mineralisation and supply to plants during the growing period. A review of nitrogen supply to apple trees by Scholz and Helm (2000) showed the importance of a sufficient nitrogen supply from bud break to June drop for high yields. This supply is mainly delivered from the nitrogen reserves in the bark and wood. Therefore, the leaves should remain in a good condition on the tree in the autumn to ensure good retranslocation of nitrogen. The effects of nitrogen on fruit quality, the incidence of physiological disorders, the mineral content of the wood and the occurrence of diseases and pests are discussed.

The decomposition and nitrogen release of surface-placed understorey plant residues were determined in the field and compared across treatments of grassed-down biological (BFP) and integrated fruit production (IFP) orchards in two different locations (Lincoln and Clyde) in New Zealand by Tutua *et al.*, (2002). In general, plant residue decomposition and N release were significantly more rapid in IFP than in BFP treatments. Soil-buried plant residues showed more rapid decomposition and N release compared with those of surface-placed plant residues. Overall, differences in plant residue decomposition and N release rates related to understorey plant residue quality and treeline management practices rather than the orchard system as a whole

Pest and disease management and its effects on soil

In current research by HORT Research (2003), disease suppression mulches and composts to combat Phytophthora root rot, one of the major causes of production loss in avocados and chestnuts in the Bay of Plenty, have been trialled. Mulches for sustainable viticulture are also being researched, to reduce the need for spraying, improve plant health and soil structure and reduce leaching of agrichemicals into underground water.

High usage of pest management chemicals permitted in organic standards, such as copper sulphate and lime sulphur is generating questions as to their effect on soils and sustainability. A comparison of biological activity of the soil in an apple orchard which had been sprayed with copper fungicides for 40 years with that in soil from a 3 year old orchard previously under arable use found mainly higher soil biological activity and biomass in the old apple orchard even though it contained 72.3 mg/kg copper compared to 9.6 mg/kg in the 3year old orchard (Frund and Gromes, 2002). They attributed this result to the higher organic matter content (2.7% compared to 1.7% in the new orchard) of the old orchard soil. Research by Merrington *et al.* (2002) on surface soils from an Australian avocado orchard found that the copper level (280 and 340 mg/kg) appeared to have affected soil biology compared to nearby soil under natural vegetation containing 13 mg/kg copper. The soil microbial population was smaller, but more active, in the orchard soil. However, there would be large differences between the microbial population under natural vegetation and orchards, irrespective of copper level.

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# ORGANIC RESEARCH REVIEW PROJECT – SUMMARY

Until the mid-1980s organic agriculture struggled to gain scientific credibility in New Zealand and elsewhere in the world. Internationally, the situation has changed dramatically since then. The International Federation of Organic Agriculture Movements (IFOAM) has developed into a highly credible organisation and one that has been instrumental in setting minimum standards for organic practices and products. There are now many research institutes dedicated to organic research, particularly in Western Europe, that are funded by individual governments or the European Union and work collaboratively with traditional research agencies. The biennial IFOAM conferences increasingly highlight the multidisciplinary character of organic research, encompassing areas as diverse as soil ecology, economics and sustainable development. Many New Zealand farmers and orchardists are attracted to organic methods but seek the backing of scientific research. It is becoming evident that organic[1] agriculture requires comprehensive research.

This research review report and catalogue were compiled to provide scientists, policy makers, funding agencies and farmers with information on the current state of organic farming systems research and research methodology, focused around organic soil management. The report provides lists of research institutions and websites that specialize in organic systems research, as well as references to relevant books and research articles. Much of the material is drawn from overseas sources. Where relevant, findings from New Zealand research are provided. This serves to highlight some important points in relation to organic systems research:

- over the last decade a strong scientific basis has been developed, building on the work of the pioneers of organic agriculture in the early part of the 20th century;
- multi-disciplinary and whole-system research approaches that take account of regional, local and on-farm characteristics are required, over long time periods;
- New Zealand organic farmers have mainly relied on knowledge gained from their own experience and trials;
- involvement of organic producers is essential to ensure practical questions are addressed and to conduct credible organic systems research (particularly for participatory and observational approaches that are increasingly being used);
- there are significant opportunities for advancement of knowledge and collaborative research in New Zealand, based on overseas experience;
- increased knowledge of organic farming systems will not benefit the organic sector alone, but will also be of wider benefit to sustainable land management in New Zealand.

[1] The terms organic agriculture and organic farming systems are used in a generic manner in this report and include many aspects of biodynamic agriculture, that are covered in more detail in a separate section of the report.

Given the significant developments in organic research taking place overseas, it is becoming evident that similar capabilities are required in New Zealand. Some overseas research is applicable in New Zealand, but because organic farming systems often reflect the unique character of the producers and their farm environments, local and regional research is essential to increasing the New Zealand knowledge base. However, the adoption of new research methodologies (as in use by the organic research centres discussed) can contribute significantly to closing the knowledge and experience gap. Early organic research was often focused on comparative trials, using conventional experimental plot design and statistical techniques. Unfortunately, such approaches often required the exclusion of multiple variables that actually determine the viability and vitality of organic farming systems. Quantitative science has an important place, but equally important to research on organic farming systems are more qualitative approaches. This stems from an understanding that organic agriculture is both a technology and a process.

The following is a summary of the various sections of the report:

## The Soil System and Organic Soil Management

Soil quality, landscape quality, soil biota, nutrient cycling and biodiversity are integral aspects of sustainable development. The report discusses research findings that show how they become functional in organic farming systems. Recognition of the uniqueness and diversity of soils and in soil provides opportunities for greater diversity at the regional or farm scale, since different soils have different suitable uses. A holistic, ecological approach is required for future research on soil-plant-animal systems in New Zealand. This will enable redesign of farming systems from an over-emphasis on production (developmental phase) towards more quality and internal regulation (mature phase). This will result in less mineral losses, less pest and disease pressure and less susceptibility to climate extremes, thus contributing to sustainable land management on farm and regional scale.

## Dairy Pasture Management

There is limited specific international literature on organic dairy pasture systems and little that is of direct relevance to New Zealand's unique pasture-based style of dairy farming. However, some information is available on pasture composition, use of leys, pasture and grazing management, pest and disease management, weed management, and animal health and management. A number of key research gaps are identified that principally focus on knowledge relating to the process of conversion, management issues and environmental effects and benefits. Established organic dairy farmers have independently addressed many of these gaps, but the knowledge and experience gained is largely undocumented.

## Orchard Soil and Understorey Management

There has been a limited amount of organic understorey management research in New Zealand of relevance to orchard systems. Complementary to this New Zealand research is the substantive work conducted at the Louis Bolk Institute in the Netherlands. A key feature is a focus on optimal management of nutrient flows in the orchard soil system, which impacts on tree and fruit health and quality. Very little work has been done in this area, e.g., on net mineralisation under different management conditions, and is required under New Zealand conditions for different production systems and regions. Aside from work on apples, there is little relevant overseas research on which to draw. A greater emphasis on holistic, orchard system research is required.

## Research on Biodynamic Agriculture

Biodynamic agriculture is based on organic principles, the uniqueness of each farm and farmer, and the use of the biodynamic preparations. This review gives a brief background to the development of biodynamic agriculture and associated research and the development of complementary research methods. An overview of research on the biodynamic preparations is provided. The use of pictorial imaging methods as quality control and diagnostic tools, other complementary research methods, long-term trials and farmer participatory research are reviewed and recommended for research in New Zealand.

## Socio-Economic Research

Research on organic sector development, economic performance, grower decision-making and conversion, market analysis, labour, and public health issues is reviewed. Integrated whole-farm analyses, of multiple dimensions, including economic evaluation over a lengthy time span, are needed to evaluate of New Zealand organic agriculture.

## A Farm Case-Study

This case study is included as a good example of a holistic research method. The setting-up, data collection and analysis for the first year of a holistic study of two paired organic conversion and conventional dairy farms are discussed. Pasture production and animal health, as well as soil parameters, were measured. No data are presented, as lack of funding prevented meaningful continuation of field data collection.

## Water Management

Water is an essential component of every farming system. The earth's water cycle and the role of forests and bush areas in maintaining the quality and quantity of water supplies for farming and society as a whole are discussed, as well as research in relation to irrigation and water quality management relevant to dairying and orcharding in general.

## Research and Organic Institutions

Lists and descriptions of overseas institutions carrying out organic farming research, as well as New Zealand organic farming organizations, are included.

## Recommendations

For the development of sustainable, viable organic farming in New Zealand, we recommend:

❶ recognition of the ecological, holistic paradigm under which an organic system operates;

❷ establishment of multi-disciplinary, holistic research approaches, which include the farms, the farmers and their environment (soil, landscape, climate, etc.) with the emphasis on:

- long-term monitoring of agro-ecosystem parameters (soil-water-plant-animal) and their effects on organic systems;
- understanding of the dynamics of soil and other agroecosystem interactions;
- information from on-farm research in different regions of New Zealand;
- working with farmers to address their research questions;
- farmer involvement in the research (participatory methods);
- development of a combination of analytical and new research methods; and
- building on the research already done in New Zealand and overseas.

To build up the expertise and capacity to implement these recommendations and build a solid framework of scientific knowledge on which the organic farming sector can operate efficiently we recommend:

- a long-term research strategy;
- a specialist organic team capable of working with new complementary approaches; and
- a dedicated research centre that co-ordinates effort.

Some recommended specific research areas include:

- effects of organic dairy farm management on soil quality, pasture composition and the wider environment; key pasture interactions, and management of pastures and animal health;
- re-thinking of orchard systems in a holistic framework, through ecologically based research focused on understanding the dynamics of systems, and introducing greater ecological complexity into commercial systems;
- integrated whole-farm analyses, of multiple dimensions, including the different social and economic facets of organic farming, over a lengthy time span;
- farm comparisons using established methodologies that enable evaluation of the dietary and health effects of organic management on livestock performance and environmental and sociological consequences.

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*Work in New Zealand as a policy analyst for MAF Policy, introduced her to organic farming through summarizing submissions on a public discussion document on organic farming policy.*

*Since then, she has combined contract work in policy analysis and research for a number of government departments, gaining experience of organic and biodynamic farming through working on farms, the Taruna Course in Biodynamic Agriculture, administrative work in the Bio Dynamic Association and Bio-Gro offices, various developmental projects and biodynamic management of a herb nursery and mixed garden.*

*She is currently studying for a Master's degree at Massey University in soil science and human nutrition and is a member of the Council and Research and Development Group of the Bio Dynamic Association.*

# 1 INTRODUCTION

Interest in organic farming and growing in New Zealand has been increasing, particularly since sizeable opportunities to supply overseas markets with organic produce have become apparent. In 2000, organic production involved between 1-5% of the agricultural sectors of Western countries. The sector was growing at an average of between 25-35% p.a., and average organic price premiums were around 25% (Ritchie *et al.,* 2000). At the same time, domestic consumption of organic food has risen dramatically in New Zealand. Whether producing for the domestic or international market, the numbers of organic farmers in New Zealand have increased rapidly in the last 8 years. Recent Trade New Zealand figures showed that the area of organic production reached 49 000 ha in 2000, an increase of 201% in only 1 year.

Farmers and policy makers have, however, been cautious about embracing organic farming methods. While recent research suggested that many primary producers in New Zealand are thinking about organic production (Cook et al., 2000), few have actually taken the plunge. One reason for this might be the lack of verifiable information both on the potential outcomes and risks and on the technological methods that can be used to make organic growing viable and sustainable. The potential benefits of organic farming to the environment from reduction in harmful agrochemicals can only be realised if farmers have confidence that knowledge of viable systems is available.

This report focuses particularly on soil management as the basis for sustainable farming. The management and research approaches adopted by the organic and conventional sectors are discussed. A successful organic sector needs an awareness and understanding of the whole agro-ecosystem. Most people in the organic sector are part-way along a continuum between input dependent farming and sustainable systems. To achieve an environmentally sustainable system, however, involves redesign of the farming system rather than simply substituting some practices for others (MacRae *et al.,* 1990). Research that will help the organic farmer needs a holistic, ecological approach that complements the analytical research.

The biodynamic farmer aims to balance the relationships between the farm and its environment, (including the whole cosmos); to restore and maintain the vitality and living fertility of soils; and in doing so to produce foods of the highest nutritional quality, based on suggestions by Rudolf Steiner, (1993). The farm is treated as an individual integrated unit in which inputs from off-farm are minimized. A dynamic equilibrium is aimed for, as discussed by Gliessman (1989).

Understanding and describing a new approach to sustainable agriculture has become a global concern. The FAO's position on Sustainable Agriculture and Rural Development (SARD), (FAO, 1994) and Agenda 21 of the Report of the United Nations Conference on Environment and Development (UNCED, 1992) illustrate that global awareness of the need to redirect agriculture has reached the highest institutional levels. In Europe, this awareness has been addressed in the design of policy for the management of nature and landscape, often in a rural development context (Baldock and Beaufoy, 1992). In New Zealand, the environmental focus provided by the Resource Management Act 1991 has encouraged the reduction of adverse environmental impacts from agriculture and increased focus on sustainability. However, the majority of the research summarized in this report has been undertaken in Europe (where organic research has received more support than in New Zealand). There is also a growing number of Asian, South American and African researchers developing a whole systems/biological approach to soil science and farm management. As a consequence, there is a rapidly emerging knowledge and experience gap on every level, from technologies through to research and research methodology. Despite the generally overseas provenance of much of the information summarized, there is a small body of New Zealand research that is evident in this report. Mackay *et al.,* (1998) has made a quantitative and structured comparison of conventional and chemical-free pasture-based mixed livestock production systems in New Zealand.

## Aims and Target Audience

The aim of this report was to provide:

*A catalogue of information to assist decision-making by researchers, policy-makers, funding bodies and the organic industry.*

This would:

- facilitate and identify research (including non-English language sources) applicable to the New Zealand organic industry, available for immediate uptake;
- facilitate adoption of organic land-management practices by farmers and growers that would improve the structure and natural fertility of soil, repair degraded soils and reduce nutrient loss, resulting in improved soil and water qualities and ecological sustainability.

At the time this project was proposed, access to non-English research reports was very limited. This report aimed to access non-English information; to communicate the available scientifically credible research results and information; to list printed and electronic sources of information; and to identify gaps and indicate areas where further New Zealand research is needed.

A key criterion for the scientific acceptability of a piece of research, which we have also adopted in compiling this report, is the acceptance and publication of a paper by a scientific journal. Most research listed fits this criterion.

The main focus has been on research relevant to soil, pasture and understorey management in organic dairy farming and orcharding. Much of this research is also useful for sustainable farming and integrated pest management systems.

An understanding of soil and water dynamics and functions in agro-ecosystems is crucial to land management. The maintenance of animal and crop health depends principally on maintaining healthy, quality soils and on the biodiversity of species in pastures and orchard understoreys. This is a preventative rather than curative approach to pest and disease management. Consequently, the report focuses on soil quality and ecology in the context of the wider environment (Section 2). Within this broad framework, the report then considers research specifically relating to:

- organic dairy pasture management (Section 3);
- organic orchard management (Section 4).

The decision to concentrate on these two sectors was taken to define the scope of the project, and because a parallel review of organic arable and cropping management research is already being covered by the SMF project undertaken by the New Zealand Institute of Crop and Food Research.

Part II includes:

- a section on research specifically on biodynamic practices, some of which has used new complementary methods in addition to the conventional analytical approach (Section 5);
- socio-economic aspects of organic farming that are less connected to our main soil-management theme but are important areas for the viability and sustainability of organic farming and that also need to be researched (Section 6);
- a case-study, describing research that was not completed due to lack of funding, illustrates some considerations needed when undertaking organic systems research (Section 7); and
- a section on water that discusses water-management aspects, including water supply and quality (Section 8).

Part III provides list of international organizations that carry out organic farming research, and information about New Zealand organic institutions.

The appendices include reviews of composting and Asian research, a short book list and review of two biodynamic farming books.

Most contributors to the project participated in searching for information, writing sections of the report based on that information, and evaluating the information and report for relevance and scientific credibility. The authorship of each section of the report has been maintained with a minimum of editing. Each contributor has approached the task differently, from a different background. We make no apologies for this as we believe it reflects the individual and diverse nature of the organic sector, with the diversity of each part making a valuable contribution to the whole.

# Key Issues

A number of key issues have arisen in the evaluation process:

- sources of information: 90% of the research quoted is from overseas; in addition to the Euro-centric information there is also information from Asia e.g., effective micro-organisms (EFM) research;
- the paradigm shift accompanying organic farming systems is not widely accepted in New Zealand; therefore the methodologies for undertaking and evaluating research on holistic systems are lacking;
- not all the information obtainable from the current databases is appropriate for organic farming systems in New Zealand.

It is apparent that many books and reports published in recent years discuss soil ecology and soil quality from a holistic point of view, relevant to a better understanding of processes underlying organic farm management. However, there has been little research on more practical issues relating to organic farm and orchard management that would be directly useful for farmers. Organic farming relies on working with a large number of interrelated long-term living processes such as the many organisms and processes involved in nutrient cycling. These are not well understood and may be different and unique for each farm. Research approaches need to take account of the multiple variables involved in a whole ecological system (although restricted to a specific field situations) over long periods of time.

In Europe, scientists are developing new, complementary ways to investigate research questions. These include on-farm research in cooperation with farmers (participatory) and observational (phenomenological) methods. The Louis Bolk Institute in the Netherlands is a notable pioneer in this work. Such research can help farmers understand the processes they are working with so they can overcome problems. For example, an understanding of the life cycle and habits of a particular plant or animal pest can help a farmer change the conditions on his farm so that pest is no longer a problem.

## Sources

Information was obtained from:

- on-line databases, e.g., CAB Abstracts;
- lists and databases provided by European and US organic farming research institutes;
- New Zealand and European organic farming research contacts; and
- books on organic farming.

Some key papers are in non-English languages. While the full body of literature on agricultural sustainability is vast, the references are mainly restricted to those dealing specifically with organic farming and/or taking a holistic, ecological approach. We have aimed to provide a selection of the most useful references to give a picture of what is available, rather than a comprehensive list. There is much older literature on organic farming and an increasing number of recent research reports and books moving towards a more holistic approach, dealing with relevant topics such as the ecology, biochemistry and biology of organic matter, humus and soil microorganisms; we have referred to a few of these books.

## How to Use this Report and Search for Information

The report includes many websites and contact details for research institutes, all of which can be accessed for information. The references to research papers can be found in on-line databases. The great majority of these references can be found in CAB Abstracts database. Some were found in Biological Abstracts or the Web of Science. University libraries keep most journals in which the research reports are found. If a journal is not available, it can be accessed through the Library interloan service.

We found that the success of a database search depends on the key words used and how they are combined under the Boolean search system. These key words relate to the key words in each report. For instance "researching the functionality of soil life" has different leads, leading to different research papers: key words such as "effective microorganisms", "beneficial microorganisms" and "plant growth promoting microorganisms" lead to different papers but most relate to the functions of soil life. Libraries that provide access to these databases generally also provide information on how to search them.

Each section of the report contains references to journal articles, books and websites. We have also provided a list of books. Some of these are old and out of print. If you have difficulty finding copies of any of these books, please send an enquiry to the Bio Dynamic Association office (– email: biodynamics@clear.net.nz), which has copies of some and may be able to help you find others.

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# RECOMMENDATIONS

❶ A national research programme is required to gain understanding of agro-ecosystem interactions that underpin the sustainability of organic farming systems on NZ soils. This should include:

– studies to understand the dynamics of soil and ecosystem interactions;

– monitoring of results of organic systems; and

– practical solutions for the various regions of New Zealand.

❷ For research to be relevant, recognition of the ecological paradigm under which an organic system operates is required, as is the adoption of a holistic systems approach that recognises:

– the dependence of organic farms on biological activity (e.g., to supply nutrients to plants);

– that every farm is unique, with its own individuality, depending on the soil parent material, the environment, the farm's place on the time/space continuum, and its socio-economic context;

– the emphasis on optimum and quality production as well as on yield and quantity of production;

– enhancement of functional biodiversity in agro-ecosystems as a key strategy for sustainable production (in contrast to biodiversity simplification that requires constant human intervention); and

– the interdependencies between plant and animal health, farm health and ecosystem health.

❸ New holistic research approaches, using complementary as well as analytical methods, are needed, such as:

– a participatory approach, working from the farmers' questions, improving communication, mutual transfer of knowledge and sharing of research activities between farmer and scientist;

– an observational/qualitative (phenomenological or Goethean) approach in combination with a deductive/analytical approach.

❹ An increase in both expertise and capacity to implement these recommendations and create a solid framework of scientific knowledge on which the organic farming sector can operate efficiently through:

- a national research strategy with long-term, regionally relevant programmes;
- a multi-disciplinary organic research team capable of working with the new complementary approaches and developing and implementing programmes in the regions;
- a national research centre that co-ordinates regional efforts; and
- active participation of producers to ensure that research is relevant to needs and is readily transferred to on-farm practice.

We have identified the following specific areas as in need of research:

## Soil Management

We recommend research that increases understanding of biochemical soil processes such as:

- nutrient immobilisation, mineralisation and humification in the context of organic farm and orchard management in New Zealand;
- the effects of various farm and orchard management practices on the flows of energy and nutrients;
- the net results of these biological activities;
- effects of biodiversity enhancement.

Such an understanding is crucial to maximise the nutrition of crops and animals, and to minimise leaching and volatisation losses, damage to soil structure and pest and disease problems.

Further development and use of basic soil quality indicators to monitor the effects of soil management and identify soil management problems in the context of the soil functions and development are necessary.

## Dairy Pasture Management

The following questions, in relation to the New Zealand system of farming, are not answered by the current literature. For pastoral organic dairy farming to be economically, environmentally and socially sustainable in New Zealand, research in these areas needs to be undertaken.

- Soil quality under organic pasture management: Does organic management positively influence physical soil characteristics long term, e.g., the water-holding capacity of the soil in times of drought, or the susceptibility to damage occurring through animal treading on pasture in wet conditions?

- Pasture composition: Will pasture quality change under organic management? How? What composition dynamics are likely to occur during the conversion phase when conventional fertilisers are removed?

- Herbal leys: What is their value in New Zealand systems as an alternative forage (during drought, etc.)? What is their potential from an animal health perspective?

- Pasture/Soil Interactions: What are the key relationships? How is a healthy soil developed and maintained under intensive grazing pressure? How do soil/plant and animal interact? What is the role of trace elements in pasture production and animal health?

- Pasture systems: How much is actually grown in an organic system? How do organic dairy pastures need to be managed? Are grazing management techniques the same as on a conventional farm? How can a pasture system be managed so that it has minimal impact on the environment? How are pests, diseases and weeds specific to New Zealand controlled?

- Animal health: How do organic farms need to be managed to prevent diseases common in a pasture-based dairy production system?

- Effluent: What are the effects of organic farm management on the wider environment? Does organic management with no input of water-soluble fertiliser and decreased stocking rates reduce the amount of detrimental nutrient leaching into surface and ground water?

- Evaluating the literature on research undertaken in Europe on the different treatments of slurry and the methods and timing of its application onto pasture – are some of these research findings applicable to New Zealand conditions?

These are just a few of the questions that need to be answered, first to give farmers the confidence to convert to organic dairy production; and second to enable them to farm successfully and in a sustainable manner.

## Orchard Management

The orchard system needs re-thinking in a holistic framework, through ecologically based research focused on understanding the dynamics of systems, and introducing greater ecological complexity into commercial systems.

In particular:

- developing a better understanding of nutrient flows in organic fruit production systems, in different regions of New Zealand and for different fruit crops, and their linkage to pest and disease interactions, tree health and vigour and fruit quality and yield;

- identifying which understorey management strategies work best for different parts of New Zealand and different production systems. Some useful work is beginning in this area, but it is not specifically focussed on organic production systems;

- developing greater understanding of interactions between soil and understorey management and other factors, such as: planting density, choice of cultivars or varieties, local climate and orchard microclimate, orchard biodiversity and pest and disease regimes;

- developing site-based solutions over longer-term ecological time horizons, that are aimed at developing organic orchard systems that are environmentally, economically and socially sustainable.

## Research in Biodynamic Agriculture

Research should use complementary methods developed in Europe as well as analytical methods and focus particularly on:

- the production, storage, use and effects of the biodynamic preparations, in particular, the hornsilica preparation, on crop development and farm ecosystems in New Zealand;

- connections between the effect of the preparations on the plants and nutrition.

Whole farm biodynamic research is required in the context of the unique agro-ecosystems of the various regions in New Zealand. A cornerstone for such research is the application of participatory research approaches that draw together the knowledge of existing biodynamic farmers with complementary and conventional research methods.

New Zealand pioneering organic and biodynamic farmers and growers have developed their own systems and solutions, through observations, trials and in the absence of scientific research, researchers should collect and build on this experience.

## Social and Economic Dynamics of Organic Agriculture

More research is needed in the following areas:

- New Zealand organic farm economic performance;

- labour use;

- community outcomes;

- public health, including effects of organic management on food quality;

- some aspects of market analysis.

There is a particular need for integrated whole-farm analyses, of multiple dimensions, including the different social and economic facets of organic farming, over a lengthy time span. (New Zealand has the necessary body of preliminary work to support such an undertaking.)

## Organic Farm Case-Studies/Farm Comparisons

Studies should include:

- use of established methodologies that enable evaluation of the dietary and health effects of organic management on livestock performance;
- the externalities of environmental and sociological consequences of such comparisons as integral features of such research.

## Water

Research into soil and water processes should adopt natural processes and recognise the importance of forests in stabilising water supply.

*Frank van Steensel studied tropical and subtropical agriculture, majoring in soil science, at IAC College in Deventer, The Netherlands. During this time he developed a keen interest in sustainable agriculture, and particularly the importance of the soil. Frank worked as a consultant and teacher for an integrated rural development project in Honduras, Central America, observing the value of participatory research and training with farmers. In 1992, Frank and his spouse Josje, immigrated to New Zealand where he continued his own training at Massey University, under the supervision of Dr Neil MacGregor. After he graduated in 1995 with a Masters of Agricultural Science (Soil Science) he started Eco-Agri-Logic, an independent consultancy for the organic sector. One of his keen projects has been to facilitate in the establishment of Wairarapa Organics Inc., and has been the co-chair since its conception in early 2000.*

*Currently Frank teaches the "National Certificate in Organic Horticulture" in the lower part of the North Island. He is a member of the Council and Research and Development Group of the Bio Dynamic Association.*

*In 1996 Frank and Josje started converting 18 acres of grass desert in the windy Wairarapa into a Centre for Ecological and Holistic Development. This self-sufficient property is developed along permacultural lines with main crops of olives and other tree crops. In June 2001 they became the first in New Zealand to produce certified biodynamic olive oil (under transition).*

# 2 THE SOIL SYSTEM: THE DEVELOPMENT AND FUNCTIONS OF SOIL

*Soil is a living system that represents a finite resource vital to life on earth. It forms the thin skin of unconsolidated mineral and organic matter on the earth's surface. It develops slowly from various parent materials and is modified by time, climate, macro- and micro-organisms, vegetation, and topography. Soils are complex mixtures of minerals, organic compounds, and living organisms that interact continuously in response to natural and imposed biological, chemical, and physical forces.*

*(Soil Science Society of America, 1995, Agronomy News, June 1995).*

To understand the soil we need to know its function as a system as well as a systems component of the larger agro-ecosystem and ecosphere. In biological terms we need to know the organism's function as a whole as well as the function of the organs in the organism. Soil is both an organ, in relation to the wider farm ecology, and an organism when considered in relation to its own organs (sub-units), which might be minerals, organic matter, micro-organisms, etc.

Soil systems and soil systems components have properties that are expressed by the whole but not by the sum of their parts. These emergent properties cannot be predicted by studying the components in isolation or decoupled from the whole (Odum, 1997[1], Checkland, 1981), as this provides a distorted picture This review provides an insight into the interactions that relate to the soil as a system and the soil as a component of the larger whole. The function of the soil is discussed first.

The soil is then reviewed as part of a larger system namely, the agro-ecosystem and landscape.

The systems components of the soil – this soil biota, soil nutrient cycling and diversity – are then discussed. These components work together as a functional whole – the earth's life supporting system. In this way, some emergent properties of the earth's life supporting system can become clearer. There are no clear boundaries between the different components e.g., between soil biota and the soil system, which leads to some repetitiveness and overlap in conclusions drawn, but also to some fresh insights from different angles.

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[1] While different levels of organizations have different, unique features, they are all linked by transcending functions, such as energy, growth, evolution, feed-back control and other common denominators. These lead to emergent properties. Properties expressed by the whole but not by the sum of its parts. It is a result of the functional interaction of the components and cannot be predicted by studying the components in isolation or decoupled from the whole (Odum, 1997).

## What is the Function of a Soil?

The soil's principal function is to support the development of a landscape or ecosystem, in other words, together with air, sun and water, the soil is a major life-supporting component of the ecosphere. The development of an ecosystem begins with a soil of purely geological origin, later called the soil parent material. The introduction of water to this geological material starts chemical actions influenced by the environment (climate, topography, flora and fauna). This physical and chemical system then evolves further towards an increasingly complex ecological system. Ecological processes in the soil become increasingly obvious and complex, and this increases the soil's functional stability or independence from environmental fluctuations, giving increasing autonomy to the systems.

The development of the soil system in time and space is accompanied by a concurrent development in the ecosystem or landscape. The development of flora and fauna on and in the soil is called ecological succession. Both have evolved together as a system, and the following soil functions can be seen as emergent properties of this development. Under natural conditions, the soil:

- sustains biological activity, diversity, and productivity;
- regulates and partitions water and solute flow;
- filters, buffers, degrades, immobilizes, and detoxifies organic and inorganic materials, including industrial and municipal by-products and atmospheric depositions;
- stores and cycles nutrients and other elements within an agro-ecosystem and the earth's biosphere.

Through these functions the soil system acts as the chief organizing centre, since all ingredients necessary to sustain primary and secondary production are stored in and recycled through the soil. Ecological succession is also a way to restore ecosystems after storms, fires or other periodic catastrophes have devastated the landscape. During ecological succession from early stages to maturity and beyond, the soil's biochemistry (e.g.. 'digestive system' or 'metabolism') changes. This change in biochemistry is directed (Odum, 1969 & 1997) by the community (soil life) and limited or patterned by:

- the geological origin, or parent material, of the soil;  and
- the environment (climate topography).

This means that over time the physical, chemical and biological characteristics of soil change. The main biological components of soil are:

- the food web, the largest contributor to the biochemistry, develops from being relatively simple and linear in the early stages of soil development and ecosystems succession to becoming increasingly complex in the mature stage;

- soil organic matter, which increases as soil develops. The rate of humus formation reaches a state of equilibrium in the mature stage, which is then maintained (Bokhorst, 1992) until old age or degeneration approaches.

The soil food web largely depends on soil organic matter. The organic matter provides food and structure in the soil, creating optimum conditions for the soil food web, which develops along with humus formation and the succession at the soil surface.

Table 1 (Appendix 1) shows the trend in ecological development (Odum, 1997).

Table 1 shows the function of a soil in an ecosystem. From a chemical perspective the soil develops from being mainly mineral towards a ripened or developed soil, reaching a steady state in humus content. In these early stages of development, the Cation Exchange Capacity (CEC: nutrient storage) of the soil increases. Young soils are high in inorganic phosphorus, as soils matures inorganic phosphorus decreases while on the other hand organic phosphorus is formed and increases, reaching an optimum level in the mature stage. Leaching of cations lowers the pH in the early stages of development (van Steensel, 1998; Bokhorst, 1992; Molloy, 1993). These chemical aspects reach an optimum during the mature stage. The CEC, the balance between organic and inorganic phosphorus and the pH stabilizes.

Maturity is reached with the achievement of an approximate steady state, meaning that:

- the mineral cycles have become efficient or (semi-) closed;

- turn over and nutrient storage has increased; and

- the internal cycling and nutrient conservation has improved.

In a mature ecosystem, gains equal losses over a long period.

As soils age, nutrients may leach out faster then they accumulate; impervious layers may form and restrict root growth, resulting in less biomass production and humus formation. Old age is approaching; the soil degenerates (van Steensel, 1998; Bokhorst, 1992). The time from juvenile to old age is from 0 to 50 000 or 100 000 years, depending on soil type, topography and climate.

These developmental characteristics are recognizable and quantifiable. Some parameters and benchmarks have been established but further parameters are required to manage and monitor soils in an ecologically sustainable manner. These parameters can then provide a basis for a more progressive agriculture, based on deductive/analytical science, but one that also takes into account the time-space continuum and its ecological development. Some quantifiable parameters could be:

- humus content: The soil evolves from having no or low humus content to a balanced optimal level in the climax stage;
- biological activity increases during the developmental phase to an optimum or steady state in the mature phase;
- community structures or food web characteristics: As a system matures the microbial population evolves from limited numbers of fungi to increased numbers of fungi in the climax or mature stage (Ingham, 1990).

This area requires more research.

## The Soil System and Agriculture

Soil development has resulted in a wide diversity of landscape or ecosystems at different times of their development; based on different parent material; under different environmental conditions; leading to a relatively stable, diverse, life supporting healthy biosphere.

Theoretically, soil systems should support a broad diversity of land-use systems. Natural boundaries have to be recognised (land suitability mapping). These are demonstrated to some degree in New Zealand by the diversity of agricultural and horticultural systems in different parts of the country (e.g., the Crops for Southland project promoting crops on matching soil type and environmental conditions as a form of diversification). However, over the last century there has been an accelerating trend towards specialization and monocultures. Landscapes in many countries, especially countries with intensive agriculture, are becoming increasingly uniform in appearance. Concern over biodiversity loss is now an issue of global importance, closely linked to another issue of global concern: soil degradation involving organic matter decline, erosion, acidification and environmental pollution. From an ecological perspective, the removal of natural systems and their replacement with large-scale, high input monocultures has set back or stopped soil development, as systems properties and functions are lost. To maintain those systems requires high inputs involving high energy costs. By underestimating the effect of the time-space continuum (soil development) and the environmental influences on the soil system, mainstream agricultural soil systems have lost part of their function, leading to declining soil quality that contributes:

- increased cost of production;
- environmental degradation;
- loss of diversity;

- reduced plant and animal health;
- reduced human health.

Pioneers of the organic and biodynamic methods (Pfeiffer, Albrecht, Voisin, Howard, Steiner) recognised these consequences. Their scientific efforts and extensive experience can be summarized as follows: if the soil system functions only partly, for instance with limited biochemistry (lack of functional soil life), then plants will be short-changed nutritionally and, as a logical consequence, so will the dependant food web (animal and human life forms).

Every farm has its own individuality, depending on its soil parent material, its environment, its place on the time-space continuum and its socio-economic context. Rather than a high input-output system as in conventional farming systems, organic systems represent throughput systems with the emphasis on optimum and quality production as opposed to maximum production.[2]

The wider acceptance of this view is recognized in various new scientific disciplines, research methodologies and farming methods. These are more holistic and integrative approaches to science and society, and contribute to a paradigm shift. The new scientific disciplines and concepts like soil quality, (agro) ecology, biochemistry, biophysics, and systems thinking are all part of this shift, and so are the new farming methods like ecological, biodynamic, organic and natural farming. A further extension of this shift is the introduction of new research methodologies, such as on-farm, farmer-orientated or participatory research, and phenomenology (or Goethean science). These methodologies are described in the section on research approaches. A clarification of the paradigm shift from a soils point of view is given in Appendix I.

## Soil Quality

Recognition of the concept of soil quality illustrates a shift towards soil biology – a more ecological view, and includes:

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[2] Due to historical and socio-economic reasons, mainstream agricultural systems generally undervalued the functions of the soil. The soil is a living system with its own "nature" but it is also an expression of its environment (nurture). Understanding of the system using a purely materialistic description (physical/chemical or literally 'science') will be limited unless we include the time-space continuum, or, in other words, the systems development in our description.

In a purely physical-chemical system, environmental influences are very limited and can be explained by linear thinking that leads to a description in terms of cause and effect. To a large extent this is what is still happening in research. Living systems are harder to explain by linear thinking. This point can be clearly made by trying to answer the following questions:

1. What came first, the chicken or the egg?
2. What came first, the human kidney, or the human body?
3. What came first, the forest soil or the forest?

Answering these questions in a linear fashion is hard; we need to take into account the time-space continuum or developmental road or (co) evolution (without a chicken, no egg, without a kidney, no human being, they have evolved together under the influence of the larger environment).

- soil organic matter and humus dynamics, including nutrient dynamics (Kubat, J, 1991, Doran *et al.*, 1992; Doran, 1996; Pankhurst *et al*., 1997);
- rhizosphere dynamics (Pankhurst *et al.*, 1994; Ingham, 2000);
- soil food web dynamics (Ingham 1999; Elsas, van der *et al*., 1997).

These aspects contribute towards a better understanding of site-specific soil characteristics and function, recognising the soil's complexity and intrinsic value.

The Soil Science Society of America (1995) adopted the following definition of soil quality:

> Soil quality is the capacity of a specific kind of soil to function, within natural or managed ecosystems boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation.

Although unstated, the above definition also presumes that soil quality can be described by a unique set of characteristics for every kind or type of soil. It recognizes diversity amongst soils, and that a soil with excellent quality for one function or product can have very poor quality for another. Soil quality in its broadest sense is enhanced by land-use decisions that weigh the multiple functions of soil, and is impaired by land-use decisions that focus on single functions. Soil quality can be degraded by using inappropriate tillage and poor cropping practices; through excessive livestock grazing or poor timber harvesting practices; or by misapplication of fertilizers, animal manures, irrigation water, pesticides, and municipal or industrial by-products. To enhance soil quality, farmers, consultants and researchers should recognise that soil resources affect the health, functioning, and total productivity of all ecosystems.

The concept of soil quality looks beyond soil fertility and maximum production; the definition stresses the importance of system maintenance (van Steensel, 1995; Hill, 1994). To sustain system maintenance, basic soil quality indicators that can identify soil management problems from the perspective of the soil's functions and development are needed to monitor the effects of soil management. Such indicators are generally under utilised in today's agriculture, although there is an increasing recognition of their need. A good starting point is the visual soil assessment guides produced by Landcare Research (Shepherd, 2000).

## Research Review

A functional structure is required to put into perspective the fragmented research efforts in the area of organic soil management. The available organic literature is divided into topics relating to soil system functioning, exploring the 'organic' research activities in New Zealand and comparing them with the overseas research activities on organic soil management as far as possible.

- Soil quality.
- Soil organic matter, soil biota , nutrient cycling.
- Landscape quality and organic soil management.
- Biodiversity and farming.
- Orchard soils and organic soil management.
- Pasture soils and organic soil management.
- Soil-plant-animal/human health.

The review is far from complete and has a strong European influence (Dutch and German). It represents a general picture of the current states of affairs in organic research and research methodology.

## Soil Quality and Organic Soil Management

Soil quality is the most important indicator of the usefulness of organic soil management methods. The quality and health of soils determine agricultural sustainability (Acton and Gregorich, 1995), environmental quality (Pierzynski *et al.*, 1994) and, as a consequence of both, plant, animal and human health (Haberern, 1992).

> In its broadest sense, soil health can be defined as the ability of soil to perform or function according to its potential, and changes over time due to human use and management or to natural events (Doran, 1997).

### *Studies of soil quality in New Zealand*

One of the first and probably most cited research paper on soil quality and organic farming systems has its origin in New Zealand. The Reganold Report (1993) highlights the advantages of biodynamic farming systems as opposed to conventional farming systems with regards to soil quality aspects. The report compared soil properties on seven pairs of biodynamic and conventional systems. Soil structure on the biodynamic farms was significantly better than the soil structure of their conventional counterparts.

Soil structure is an undervalued factor in agriculture. It has great significance for plant (root) growth and rhizosphere development. As soil structure is the result of the interaction of soil life with the soil environment, the conclusion that the organic farms had higher (micro) biological activity than their conventional counterparts is not a surprise. Higher levels of earthworms, soil respiration, mineralisable nitrogen and the ratio of mineralisable nitrogen to organic carbon confirmed the situation. In 1994, Macgregor concluded:

> From the results of the suite of measurements made, soils of the organically managed farms were concluded to be the equal of, or superior to, soils of their conventionally managed farm counterparts. Soils continuing to possess favourable physical, chemical and biological properties resulting from organic management are clearly soils that have features consistent with the notion of the sustainability of land use.

Similar conclusions were reached by van Steensel (1995): that the pasture phase in organic crop rotation had better soil quality aspects then the pasture phase in conventional crop rotation. The next key New Zealand report (Murata & Goh, 1997) to compare organic and conventional soil management reported that: total carbon, total nitrogen, microbial biomass carbon and microbial biomass nitrogen were increasing and higher in organic crop rotation under the pasture phase compared with the pasture phase under conventional rotation. These parameters decreased less during the cropping phase under organic soil management than during the cropping phase under conventional soil management. Simply, there were more micro-organisms and more food for micro-organisms, which resulted in higher biological activity under organic soil management. High biological activity is not necessarily better (as explained later) but in the above comparisons it indicates an improvement in soil functioning and development.

Condron *et al.,* (2000) reviewed soil quality under organic and conventional farming systems and concluded:

> Although there are clearly insufficient New Zealand-based results to draw definite conclusions about organic farming systems, the trends towards improved soil quality indicators under biodynamic farming systems (especially biological indicators) are paralleled by key overseas research reports on organic farms.

## *International studies of soil quality*

Overseas comparison studies show similar results to the New Zealand studies: generally improved soil quality under organic soil management compared to conventional soil management (Liebig & Doran, 1999; Stamatiadis *et al.,*1996; Gardner *et al.,* 1996). A long-term comparison trial by the Rodale Research Centre (Doran, 1994) also draws the conclusion that there is higher biological activity in the organically managed system as demonstrated by higher soil respiration, faunal populations and water infiltration rate.

## *Studies on soil quality aspects*

Soil fertility, a soil quality indicator, is considered to be improved by organic farming systems, because it depends on a recycling of nutrients and a proper balance between organic material, soil organisms, and plant diversity that maintains a productive soil (Deavin, 1978; Lopez-Real & Hodges, 1986; Arden-Clarke & Hodges, 1988). Higher soil organic matter contents have been found to have positive effects on yield and yield components of cereals

(Gorlitz & Asmus, 1984; Schnieder, 1984; Gorlitz, 1986) as well as on physical characteristics (Asmus et al., 1987).

Friedel (1999) reports that microbial biomass carbon and nitrogen were significantly higher on long-term organic fields compared with conventional fields. Mader *et al.,* (1999), reporting on their long-term study at FiBL (Research Institute of Organic Agriculture, Switzerland), found a significantly greater soil microbial biomass carbon and enzyme activity on the two organic treatments compared with controlled, conventional and mineral treatments.

Microbial biomass and microbial activities involved in nutrient dynamics can enhance the plant's nutrient uptake (Elliot, 1994; Ingham, 2000). For example, Oberson *et al.,* (1993) reported the enhancement of phosphorus dynamics in biologically managed systems. The turn-over rate determines the amount of available nutrients, and largely depends on the amount of soil organic matter, humus, microbial biomass, microbial activity, and environmental conditions such as daily and seasonal rhythms.

Improved functional biological activity (Tilman, 1998) often leads to improved soil quality in terms of biological and chemical properties and physical stability (Drinkwater *et al.,* 1998; Mader *et al.,* 1996; Reganold *et al.,* 1987). This is a key aspect of both soil quality (as shown above) and organic farming systems (see below).

Other studies on organic soil management involving indicators of soil quality are:

- on microbial biomass: Fließbach & Mader, (1997); Franzluebbers *et al.,* (1996); Oberson *et al.,* (1993); von Lutzow & Ottow, (1994); Zelles *et al.,* (1992); and

- the physical and chemical properties of soil organic matter: (Fließbach & Mader, (2000); Wander & Traina, (1996).

All these studies indicate that soils under organic management have the potential to contribute to improved soil quality, meaning improvements in:

- sustainability;

- environmental quality and, therefore;

- plant, animal and human health.

The studies on soil quality and soil quality aspects that compared organically managed with conventionally managed farms indicate that the soil system under organic soil management has reached a higher level of functionality and development than the similar soil system under conventional management (i.e., it has more mature characteristics). In Table 1, page 174 it can be seen that this has advantages and disadvantages: e.g., for instance biomass production decreases (less productive) while stability and resilience to stress increase (less inputs required). In the end, it is a trade off the farmer has to make. The 'organic' trend would be to opt for more climax characteristics in the farming system:

- to correct the over-emphasis on maximum production and juvenile and developmental characteristics of conventional farming systems;

- to phase out the reliance on agro-chemicals by increased stability and feedback controls

This means an input-output farming system becomes more like a through-put farming system.

To improve soil quality, organic research organisations and institutes (FiBl, LBI, HDRA, Rodale Institute, etc.) explore accepted methods such as more diverse crop sequences, increased crop rotation, inclusion of ley crops and pasture, no tillage and/or reduced tillage, and organic manuring (Anderson & Domsch, 1989; Liebig & Doran, 1999).

As organic farmers do not use soluble fertilisers, and rely entirely on biological nutrient cycling processes (Bloksma, 1996, Kopke, 1997), it is important to know what factors contribute to functional biological activity and turn-over rates of microbial biomass. The organic research centres mentioned work closely with farmers and address practical site-specific questions.

Soil microbial biomass and activity can be significantly increased by crop rotation as well as by additions of organic manures (Anderson & Domsch, 1989; Raup, 2001). Addition of effective and/or plant growth promoting micro-organisms (see for example IFOAM conference papers; Pankhurst *et al.*, 1993) also contributes to this effect.

Soils have an optimum level of microbial activity. Higher microbial activity might result in high mineralisation rates and if this is not synchronised with the plant or plant community demand could result in losses from the soil system. Research is currently being carried out at FiBL on the effect of high microbial activity under practical conditions. Decomposing material will be used to form:

- new microbial biomass (immobilisation);

- labile (available) organic compounds (mineralisation); and

- stabilized organic compounds (humification) in the soil.

(Jenkinson *et al.*, 1987; Parton *et al.*, 1987).

Processes such as immobilisation, mineralisation and humification, (and particularly the net result of these processes in the soil), are important for consultants and producers to understand. A Louis Bolk Instituut report on orchard floor management (Bloksma, 1996) shows the practical implications of the ratio between mineralisation and immobilisation as follows:

> Both processes can occur at the same time. The net result can be nil even under high microbial activity. The conditions determine which process is dominant.

As stated in the report written for Dutch growers, researchers and extensionists:

- net mineralisation occurs under relatively warm, aerated, alternately wet and dry, relatively alkaline conditions influenced by the energy supply from crop roots. (Conditions normally prevalent in spring and early summer.) Actions that can be taken to encourage strong mineralisation are: soil aeration, irrigation and drainage, liming, increase of nitrogen supply, e.g., fresh manure, regular mowing of grass, legumes, preparation 500, etc;

- net immobilisation occurs under colder, solid or compacted, constantly wet, acidic conditions with limited plant root activity. (Conditions normally prevalent during autumn and winter.) Actions that can be taken to encourage strong immobilisation are: no aeration, keep moist too wet, no liming, increase carbon supply, e.g., mature compost or lignin or hemicellulose rich material like hay, straw or wood, no legumes in the ley, preparation 501, etc.

The LBI report (Bloksma, 1996) provides useful knowledge for the grower that would be helpful for the grower in New Zealand too. The report demonstrates how Western European ecological research methodology provides practical assistance to growers, enabling them to use the information to develop viable organic systems. Much of the LBI research (participatory research approach) is undertaken jointly with producers on their properties, which means both sides gain relevant knowledge. The producer gains insights into organic farming processes and the researcher gains practical and site-specific knowledge. This has resulted in fast progress and growing confidence in organic farming systems by researchers and growers.

## *Soil biota, soil organic matter, and nutrient dynamics under organic soil management*

Soil biota is a functional component of soil systems, of the farm, and of the ecosystem. Pankhurst *et al.*, (1993/94) clearly state the importance of soil biota:

> The soil biota is a highly diverse assemblage of organisms that carry out a wide range of processes that are important for the maintenance of soil fertility and soil quality. The development of sustainable farming systems will depend greatly on our ability to capture the benefits that may be derived from improved management of soil biota. This will only be achieved through an increased understanding of the soil biota, the functional processes it caries out and how soil and crop management practices affect its activity.

Organic farming systems (e.g., those described by Balfour, Howard, Steiner, Pfeiffer, Rodale, Albrecht) emphasise living soil, and this includes the importance of soil organic matter, soil biota and food webs in the soil. Brought to general public attention by Rachel Carson's *Silent Spring* (1961), our knowledge of the importance of food webs has grown rapidly, along with the understanding developed by ecologists such as Odum (1969). The increasing interest in soil biology and ecology and soil quality means the relevance of food webs for agriculture and horticulture has been recognised (Pankhurst *et al.*, 1993; van der Werff, 1992; Ryder *et al.,* 1993; van Elsas *et al.*, 1997).

One of the most profound aspects of the soil food web is the functioning of the rhizosphere. Rhizosphere soil generally has a higher number and broader diversity of soil micro-organisms, that is a more complex community structure, than the surrounding soil due to the interaction of plants with soil. Plant exudates and organic matter stimulate microbial activity and Ingham states that many plants can be recognised by their rhizosphere community structure (Ingham, 1999, 2000). It appears that every plant species "co-creates" its own rhizosphere population or community structure that aids its nutrient uptake and can by various techniques protect it from potential pathogens (Trevors & van Elsas, 1997; Whipps, 1997; Ingham, 2000). This means that a broad diversity of crops or plants has a more complex community structure of soil biota.

During the development of the soil system, the food web becomes increasingly complex (Odum, 1997; Tugel *et al.*, 2000) (see also Table 1, page 174). In the later stages of the soil and ecosystems development, the role of fungi increases (Ingham, 1999/2000). The same is true for biological activity. Young soils are low in biological activity (simple food web or chains). During the developmental stage biological activity increases (increased food web complexity), then activity stabilises (reaches a relatively steady state that fluctuates with daily and seasonal rhythms) during the climax or mature stage (complex but stable food webs).

As stated in Table 1 an increase in food-web complexity in an ecosystem goes together with:

- a decrease in yield (or net community production);
- (semi) closed mineral cycles;
- increased turnover time and storage of essential elements;
- increased internal recycling;
- increased nutrient conservation;
- increasingly mutualistic behaviour;
- decreased entropy (or reduced losses).

From a soil's perspective, a similar view is expressed in the Soil Biological Primer (Tugel, 2000), which lists the benefits of complexity including:

- nutrient cycling;
- nutrient retention;
- improved structure, infiltration, and water holding capacity;
- disease suppression;
- degradation of pollutants;
- biodiversity.

The Primer recommends more research into community structures and food web complexity. Microbial biomass and microbial activity in the soil is a soil quality aspect and organic soil management has a positive influence on them. This might be due to an increase in food-web complexity. The hypothesis that the stability of soil ecosystems increases with increasing diversity (maturity) seems to be confirmed by Fleissbach *et al.*, (2001) from FiBL. They suggest that the long-term effects of organic and conventional farming systems result in differences in the soil microbial community structure that lead to differences in the decomposition of organic matter. This results in higher or lower nutrient availability for the crops grown.

The introduction of micro-organisms to the farming system (often termed functional or effective, beneficial or plant growth promoting organisms) is being widely researched. In the USA and Europe compost and composted manures amongst other things are used to introduce and maintain soil organic matter and soil micro-organisms. In many Asian, African and Latin American countries effective micro-organisms are being trialled with promising results (e.g.,Sangakkara & Higa, 2000). Effective micro-organisms are cultured by fermenting rice-based organic material. Other "inoculums" like compost teas and fermented teas (herb, seaweed) can be used in a similar way. Biodynamic preparations are at times included in this list.[3]

Nutrient cycling and energy flows in terrestrial ecosystems are tied to the turnover of organic matter in soil. Although small in mass (we are still talking about tons per acre), the microbial biomass is amongst the most labile pools of organic matter and thus serves as an important and dynamic reservoir of plant nutrients. The succession of the soil microbial population

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[3] Fresh preparation 500 is highly biologically active, as shown by various researchers both in New Zealand (van Steensel, 1995) and overseas (Pfeiffer,1949). van Steensel compared the biological activity (by means of respiration) between earthworm casts, rhizosphere soil, preparation 500, biodynamic compost and commercial compost. He found preparation 500 to have the highest activity, followed by biodynamic compost>earthworm casts>commercial compost> rhizosphere soil.

during ecosystems development and soil development shows that a simple food web is vulnerable to external stress and largely based on a limited number of mainly bacterial species that build up a food source (humus; see also Appendix 2) in the soil. Once the humus has reached a certain site specific level, the soil microbial population stabilises into a long-term energy-efficient, harmonious, (semi) closed system and supports a mature or climax ecosystem. The soil food web structure has changed from being relatively simple, vulnerable and bacterial based into a complex, stable community structure, rich in diversity and with an increased fungi population.

The first phase mainly represents growth and production, while the mature phase represents stability and quality (see also Table 1). The mature system has an increased nutrient buffer in the form of higher (soil) organic matter and biomass content and a higher rate of internal recycling, meaning less nutrient losses from the system and more nutrients tied up in the biomass. With higher organic matter contents and complex soil food webs, soil borne pests and diseases are suppressed (van der Werff, 1992; Tugel, 2000).

Soil biota is clearly important for (organic) soil management. It is a key aspect of plant nutrition, of pest and disease suppression, as well as of environmental degradation.

Organic farming is about finding the balance between the juvenile stage (high production, vulnerable to stress/perturbation/disturbance) and the mature stage (stability, quality, efficient). Mainstream farming emphasises the juvenile stage (high production, vulnerable to pests and diseases, more losses from the system).

As a net result, the mature stage has a semi-closed nutrient cycling process, meaning lower losses from the system and increased nutrient sinks/pools.

A clear example is the excessive nitrogen losses from the farming system. The major water contaminant in North America and Europe is nitrate-N, which is also becoming an increasing challenge in New Zealand. The recognised principal sources of N-loss are the conversion of native to arable land use, fertilisers, animal manures and other nitrogen inputs (Soil Biology Primer, 2000; Waldon *et al.*, 1997). Soil management practices are known to influence N leaching. The major factor influencing N-losses are excessive rain or irrigation, mineralisation, immobilisation, nitrification, denitrification and humification (Bloksma, 1996). The net results of these processes generally result in less nitrogen leaching under organic management than under conventional management (Schluter *et al.*, 1996; Stopes & Phillips,1994; Power & Doran, 1984). Although not all research indicates a reduction in N leaching on organic farms, reduction of all losses from the system and thus reduction of N losses is one of the aims of organic farming systems.

In 1993, an international workshop on nitrogen leaching in ecological agriculture (Kristensen *et al.*, 1995) identified key factors and recommended research work aimed at improving and designing organic farming systems. Environmental and soil remediation has become a major (knowledge) industry. The contribution of organic research centres to these challenges of reducing nutrient leaching and water contamination has been recognised. For instance, LBI has been developing a model for nitrogen dynamics for ecological arable farmers called NDICEA (Nitrogen Dynamics In Crop rotations in Ecological Agriculture). Work on the model has increased knowledge of regional and seasonal mineralisation rates and net results of the competing processes of mineralisation, immobilisation and humification (Habets & Oomen, 1993; van der Burgt, 1998; Bokhorst & Oomen, 1998; Oomen, 1995). NDICEA is becoming a promising instrument to assist in farm management and facilitation by researchers. More important, it has created insights into the relevant regional and seasonal soil processes. The model will be exposed to testing under various different (soil) conditions in further research programmes.

Models can be useful but have disadvantages too. Condron *et al.*, (2000) reported on nutrient dynamics using budgetary models developed with mainstream farming research data. They expected that organic farming systems could support themselves with biological nitrogen, but expressed concern about continuing phosphorus availability. Nutrient budgets are a good linear approach but fail to explain what goes on inside the "Black Box", in this case the soil system, and the input-output approach does not explain the internal functioning of the system. We know that the soil under organic soil management is generally different (see soil quality sub-section) from soil under conventional farming systems, which mean that the behaviour of the soil system under organic management is different. As a consequence, the current mainstream working models or budgets might not be appropriate tools for research on organic farming systems.

A paper produced by FiBL (Fliesbach *et al.*, 2000) on nutrient dynamics in biodynamic farming systems concluded:

> The results of this research support the hypothesis that the biodynamic system invokes higher efficiency of the soil microbial community with respect to substrate use for growth. In other words, they make better use of the soil's natural resources. The soil system ("Black Box") functioned more efficiently under organic farming conditions[4].

Waldon *et al.,* (1998) also compared the performance of two very similar soil ecosystems under organic and conventional management. They concluded:

> The lower N and P contents of the organic site, considered with their healthy plants and high production, call for re-evaluation of soil test methods and standards for organic farming systems. The organic farming systems may use mineral nutrients in a more efficient manner and allow lower inputs.

This can partially be explained by the use of organic fertilisers as opposed to inorganic fertilisers. Moritsuka *et al.*, (2001) studied the effects of organic and inorganic fertilisers on

[4] In biological terms that also means that the organ (soil life) functions well and therefore the body (soil) is able to perform. A healthy body can be maintained only if its organs perform their task.

the nutrient dynamics in the rhizosphere, and concluded that the contribution of the net supply of N, P, and K through the replenishment from the solid phase was higher for the organic fertiliser treatment than for the inorganic fertiliser treatment. In short, inorganic fertilisers reduce the efficient use of the soil system's mineral resources.

In the light of these results, the concern of Condron *et al.*, (2000) about continous phosphorus availability under organic soil management might not be warranted. Phosphorus availability is largely determined by mineralisation (by phosphatase enzymes) due to microbial and plant activities (Speir & Ross, 1978). Phosphorus mineralsation rates are correlated to nitrogen mineralisation rates, microbial activity and humus. It is decreased by high phosphate concentrations. Mineralisation rates are also higher in the rhizosphere. Oberson *et al.*, (1993) reported that the soil microbial biomass and the activity of the enzyme acid phosphatase were higher under the organic soil management plot in their long-term field trial. These results were attributed to both the higher quantity of organic carbon and organic phosphorus (organic matter) applied in these systems and also to the absence of or severe reduction in chemical plant protection. A further conclusion drawn was that phosphorus could not be the factor limiting crop yield under organic management. The ability of phosphorus to leave the soil solid phase was significantly higher under the biodynamic treatment than under all other treatments. This was explained by the higher calcium and organic matter contents in this system. Other important factors in increasing phosphorus uptake are the presence of mycorrhizal associations and earthworms, which have been extensively reviewed (e.g., Quarles, 1999; Singh & Aneja, 1999; Lee, 1985; Pankhurst *et al.*, 1994).

The soil system with its components of soil organic matter, soil life community structure and nutrient dynamics plays an essential part in the global water, carbon, nitrogen, phosphorus and sulphur cycles. Soil organic matter[5] and biomass are a major sink or pool for carbon, nitrogen, phosphorus and sulphur. The turnover, cycling rate and availability are under the influence of soil organisms. According to the Soil Biology Primer (Tugel, 2000) the food web serves the land manager in the following ways:

- fertiliser requirements may decline as a healthy food web efficiently stores and recycles nutrients;
- nitrates do not leach into groundwater when soil organisms hold nitrogen in the rooting zone;
- water quality is protected when organisms effectively degrade pollutants;
- more water soaks into the soil and can be used by crops as biological activity enhances soil structure;

[5] See Appendix 3 for more info on soil organic matter and humus.

- pesticide use can be reduced as disease suppression improves with a healthy soil food web.

## *Landscape quality and organic soil management*

Landscape quality, directly related to soil quality, is beginning to attract attention overseas but is underexplored in New Zealand. The degradation of the environment (soil, water, air), loss of nature (flora and fauna), and depletion of natural resources go hand in hand with the degradation of landscapes and loss of livelihood in rural communities. Agenda 21, the report of the United Nations Conference on Environment and Development (1992) has further stimulated national and regional authorities to take action, which has led to increased global interest in biodiversity and conservation and in sustainable and ecological development.

Promulgation of the Resource Management Act (1991) showed New Zealand as a front-runner in these developments. There have also been various fragmented efforts to enhance overall environmental quality in New Zealand. In Europe, concern about landscape quality led to the development of the EU Concerted Action group, which encouraged structured scientific research (van Elsen *et al.*, 2000). The EU Concerted Action group developed a checklist for EU sustainable landscape management as a tool for policy making (van Mansfelt *et al.*, 1999). Organic farming is increasingly recognised as being part of that development. As stated by van Mansfelt *et al.*. (1998):

> The basic philosophy of organic agriculture …., allows the presumption that at least in potential, organic farming systems can contribute to the visible landscape quality in a positive way.

A database search or organic farming and landscape literature resulted mainly in the recovery of European oriented literature. The available literature on landscape and organic farming systems in New Zealand is limited. A well-designed and managed organic crop rotation has the potential to contribute towards improved sustainable development in the catchments area (or landscape) (van Steensel, 1995).

Organic farming systems have characteristics such as increased biodiversity that enhance the landscape (Braat & Vereijken, 1992):

- 200% to 2000% more beetles and earth worms (this has been confirmed for earth worms in New Zealand by Reganold *et al.*, 1993);

- 50–700% more species of bees, butterflies, bumblebees and spiders;

- 130–700% more herbs and non-crop species as compared to conventional farms (Austria, Germany, The Netherlands, and Switzerland);

- 30–800% more birds reported in Germany, the Netherlands and the USA.

The increased biodiversity of organic farms in Europe includes species from the endangered species list. On these organic or ecological farms there can be an increase in diversity of land use types, including more use of woodlots, linear planting and crops compared with practices on traditional farms. Kuiper, (1997) reported on the diversity of landscape elements, ecosystems and species.

These reports show that organic (including biodynamic) management tends to increase the diversity of fauna and flora considerably. As stated by van Mansfelt *et al.*, (1998), increased biological diversity seems to go together with increased diversities of land use in general, and diversity of labour and spatial structures. This view is supported by agro-ecologists such as Altieri, (1994):

> The reintroduction of a mosaic structure into agricultural landscape composed of woodlots, fencerows, hedgerows, wetlands, farmyards, etc, can lead to the creation of multiple habitats for reproduction, feeding, and sheltering for a number of beneficial species. This addition or enhancement of biodiversity can restore or improve community homeostasis.

Organic farming systems contribute well to landscape quality and are therefore supported by various governments in Europe. Stroeken *et al.*, (1993) indicated that landscapes deliberately developed on farms (landscape production) can be studied. Regional identity (based on ecological and historical strengths of the region) became an overall goal, encouraged by the Dutch Government, for example, to stimulate local products and tourism.

Soil and landscape develop naturally together into unique diverse units that vary across continents and islands, providing global biodiversity and thus creating the global life support system. A change in flora and fauna communities on top of the soil goes together with a change of community structure in the soil, and will affect nutrient turnover rates (microbial biomass and activity). An increase in biodiversity generally accompanies improved stability in and on top of the soil.

Organic farming systems contribute to this, although there is recognition in Europe of the challenges of increased diversity in the agro-ecosystem. Unless well designed, such diversity could lead to chaotic fragmentation, so research is concentrating on coherence within the farming system as a whole (van Mansfelt *et al.*, 1998). The basic farming concept in biodynamic farming is referred to as managing the farm identity or farm individuality. The appropriateness of nature and landscape development to the organic farm identity has been described by a team from the Louis Bolk Institute (LBI) (Vereijken *et al.*, 1997):

> For the concept of farm individuality to be used … in landscape planning, three issues need to be addressed:
>
> – a method to describe the farm individuality;

- the people who live and work on the farm are part of the farm individuality, so they should participate in the (research) planning process; and

- landscape is perceived as a dynamic system and individuality is also a dynamic concept.

The LBI team (1997) presented a method designed for landscape-development planning at farm level, based on the concept of farm individuality and a Goethean-phenomenological approach. The method, which involves a participatory on-farm research methodology, can be characterized as a bottom-up rather than a top-down approach. It enables farmers to coooperate in landscape planning with all their ideas, feelings and future plans for their farm. The method is illustrated in work recently carried out on a Dutch organic farm, the 'Noorderhoeve' (Baars & van Gelder, 1994).

## *Biodiversity and farming*

Biodiversity is an important aspect of the relatively new discipline of ecology, which plays a major role in sustainable development. Involving more than the problem of loss of species that appears to be the common concern, biodiversity refers to all species of plants, animals and micro-organisms that exist and interact within an ecosystem (Vandermeer & Perfecto, 1995). When species are lost, so are certain functions and developments up and down the hierarchical scale. In natural ecosystems, the vegetation cover of a forest or grassland prevents soil erosion, replenishes groundwater and controls flooding by enhancing infiltration and reducing water runoff (Perry, 1994). There is interaction between the soil and the rest of the ecosystem. As defined by Altieri, (1999):

> In agricultural systems, biodiversity performs ecosystem services beyond production of food, fibre, fuel, and income. Examples include recycling of nutrients, control of local microclimate, regulation of local hydrological processes, regulation of the abundance of undesirable organisms, and detoxification of noxious chemicals.

These are mainly ecological processes and to maintain them a certain level of functional biodiversity is required. From an economic point of view, this means that if an agricultural system is deprived of basic regulating functional components, resulting in loss of soil fertility and pest and disease regulation, there is an increasing need for costly external inputs. Swift and Anderson (1993) stated:

> The net result of biodiversity simplification for agricultural purposes is an artificial ecosystem that requires constant human intervention, whereas in natural ecosystems the internal regulation of function is a product of plant biodiversity through flows of energy and nutrients. This form of control is progressively lost under agricultural intensification.

This means that enhancing biodiversity in agro-ecosystems is a key strategy to bring sustainability to production. This involves a shift towards mature or climax characteristics, a move away from an over-emphasis on production (developmental phase) towards more quality and internal regulation (mature phase) (Table 1).

Agro-ecological-based farming systems like organic farming should include strategies that exploit the complementarities and synergies resulting from various combinations of crops, trees and animals (in space or time). These include arrangements such as poly-cultures, agro-forestry systems and crop-livestock mixtures (Reijntjes *et al.*, 1992). Insect pest problems are increasingly linked to the expansion of mono-cropping and the loss of landscape diversity or local habitat diversity (Altiery & Letourneau, 1982, 1984; Andow, 1991). Odum, (1996) concluded that with the maturing of a system the biodiversity increases, which is accompanied by a reduction in insect pests, increased stability, less losses from the system, and so on.

## *Soil-plant-animal health and organic soil management*

The view that plant health, animal health and human health are related to soil conditions has been promoted by many scientists with a strong academic background, such as Steiner, Howard, Balfour, Muller and Rusch, Boucher, Pfeiffer, Albrecht, Voisin, Hamaker and later Chaboussou. The link between plant health and soil conditions is becoming increasingly obvious in modern research. Chaboussou's (1987) work leads him to the following statement: "Healthy plants do not get sick".

Disease suppression in plants as a function of the soil (life) has been discussed at various conferences (e.g., IFOAM, 1992/94/96/98; Ingham, 1999/2000; Pankhurst *et al.*, 1994).

Chabossou, (1977 & 1985) indicates that metabolic disturbance in plants caused by pesticides influences or unbalanced crop nutrition influences plant health negatively.

Trace-elements and other mineral balances in the soil are also becoming increasingly recognised as having an influence on plants (Bloksma, 1996; Andersen, 1989) and animal health. Condron *et al.*, (2000) stated "Trace element deficiencies occur in the human population in New Zealand as well as in livestock". Furthermore, Condron *et al.*, recognised the potential of organic farming systems to produce plant and animal products appropriate for the human diet. Voisin (1959) stated:

> The soil must be kept in good health if the animal is to remain in good health. The same is true of man. Soil Science is the foundation of protective medicine, the medicine of tomorrow.

# Conclusions

A UNDP publication (*Benefits of Diversity*, 1992, p.4) on sustainable farming states: "In reality organic agriculture is a consistent systems approach based on the perception that tomorrow's ecology is more important than today's economy".

This report advocates readjustment by economy to primary production factors and not the other way around. Without ecology, there is no economy. If conventional agriculture had been made to pay for the degradation and environmental damage it caused, the move towards ecological and organic farming systems would have been made long ago. The aim is to stop degradation and re-establish natural balances. In Europe, research emphasis has shifted from the validation of the organic farming system to finding practical solutions for theoretical and especially practical challenges. In organic farming there is a different, organised 'practice' with its own ethos, which ought to have consequences for scientific research (Baars, 2000). An ecological or organic scientific platform could close the gap between 'grass roots' organic organisations and policymakers and other research institutions. The dependence of organic farms on biological activity (for instance, to supply nutrients to plants) requires a different methodical systems approach in which a mutual transfer of knowledge between farmer and scientist is valued.

Yield and production are seen in the local literature as limiting factors for the development of New Zealand organic farming. There is a different emphasis in organic farming systems, an emphasis on quality rather than quantity, on optimum production rather then on maximum production. However, both can be significantly improved (quantity and quality) if the same amount of research funding was allocated to researching organic farming systems as to mainstream farming systems. IPM strategies (a strategy between conventional and organic farming), for example, receive more funding than organic farming systems. These strategies, however, involve the first two steps towards sustainability: improving efficiency of existing systems and input substitutions. The third step is generally not taken outside the organic sector: a conscious re-design of the agro-ecosystem (Hill, 1990). This step requires knowledge and understanding of those agro-ecosystems.

In Europe, dedicated organic or ecological research centres have gathered this knowledge and understanding and are defining and researching the conscious re-design of agro-ecosystems in conjunction with farmers. In New Zealand such understanding is mainly held by a few experienced organic farmers and scientists. For scientists to help more farmers adopt truly sustainable organic farming systems, wider understanding of and research into soil ecological processes is required.

## Recommendations

❶ More research on soil food web and biological processes is required for organic soil management, as well as for general sustainable farming methods. Processes such as immobilisation, mineralisation and humification are therefore important for study. More important is the net result of these processes in the soil. Regional and seasonal mineralisation rates and related processes in New Zealand soils should be inventoried.

❷ To sustain system maintenance, basic soil quality indicators need to be determined and used to monitor soil management effects and identify soil management problems through an understanding of the soil's functions and development.

❸ A participatory on-farm research methodology based on phenomenology should be adopted.

❹ Strategies for enhancing of biodiversity in agro-ecosystems should be investigated. Such strategies are a key sustainability and a move from an over-emphasis of production towards more quality and internal regulation.

'Specialised' research centres are needed to direct and manage a holistic and ecological approach to organic soil management and build the necessary research skills and experience.

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# 3 ORGANIC DAIRY PASTURE SYSTEMS – A REVIEW

## Introduction

The following report summarizes the findings of a literature review searching information on the effects organic manage-ment has on dairy pastures.

Germany and Switzerland in particular have a long history of biodynamic and organic production and research. Long-term farm trials and soils managed biodynamically for up to 70 years are available for research. Many institutes and universities are involved in research into organic production systems and some are dedicated solely to this field.

Most of the research reported on, however, has been undertaken on soil used for vegetable production, cropping or orchards, but not under permanent pasture. In European production systems, pasture provides only part of an animal's diet; feed production for livestock is managed by a rotation of pasture and different fodder crops. Dairy cows are housed for most of the year, and are grazed only for brief periods; stocking rates are low and regulated to minimize surface and groundwater contamination. While the stocking rate in New Zealand varies mainly between 2 and 4 cows per hectare, depending on regional production potential and intensity of the farm management, Essen *et al.,* (1990) report on biodynamic milk production in Sweden, where the researched dairy farm consisted of 100 ha and 40 dairy cows. This difference in production system is reflected in the research. Many fertilizer trials include different application rates of slurry and manure, researching the effects of different ways and periods of composting for slurry and manure and the effects of added biodynamic preparations. A main aim of the research is to identify production systems that minimize surface and ground water contamination with livestock production (Elsasser, 1995).

## Soils Under Pasture

### *General*

The literature included in this section summarizes findings of a general nature; although not all the research reported on is aimed specifically at dairy pasture, the findings on the effects of organic management on soil characteristics encompass all areas of agricultural production and are therefore also applicable to organic pasture management.

## *Production Potential and Product Quality*

The emphasis of organic soil management is on maintaining the long-term production potential of the different production systems, rather than the short-term production increase of a particular crop. The following trials confirm the effectiveness of this approach:

The application of biodynamic preparations showed a positive effect after a relatively short period. Perez-Sarmentero *et al.,* (1999) assessed up to 16 soil parameters after 3.5 years of applying biodynamic preparations. Results suggest these preparations have a positive influence on soil conditions, the response being better in more extreme environments.

Granstedt *et al.,* (1997) report on three long-term experiments in Sweden, researching the effects of fertilizers and manures on soil fertility, crop yield and quality. They found that yields of grass/clover mixtures were highest in the organic treatments, and most chemical and biological parameters of soil fertility were increased by organic fertilization.

Raupp *et al.,* (1997) evaluated the relative yield, product quality and soil life after long-term (17 years) organic or mineral fertilization. They found that production yields varied: yields of potatoes and rye were lower and yields of spring wheat were similar in the organic system. However, their evaluation also showed that humus content and biological activity in the soil were greater, that products from the organic system had a better storage quality and that vegetables had lower nitrate contents.

Apart from the quality of the product from different production systems, the production potential of organic in comparison with conventional production systems is important. Research findings seem contradictory as production yields are found to be lower (Raupp, 1997; Reganold, 1995), equivalent (Raupp, 1997), or higher (Granstedt, 1997; Colmenares *et al*, 1999). Simulating the production potential after long term differing management systems showed the following: Droogers *et al.,* (1996) compared the production potential of two farming systems (biodynamic and conventional) by converting 'static' basic soil properties into a 'dynamic' assessment using simulation modelling. Soil conditions on two farms – one having been managed biodynamically for 70 years – were investigated with morphological and physical methods. A simulation model including 30 years climatic data was used to predict water-limited potato yields, showing that the simulated yields were significantly higher on the biodynamic fields.

## *Rhizosphere – Interaction with Plant Growth*

No published research was identified in New Zealand on this topic. The international work published emphasized the influence that soil flora and fauna have on plant growth in an organic system. Scullion *et al.,* (1998), for example, described how management before conversion can have an impact on soil fungi, that in turn will influence plant growth under the organic system. Yeates *et al.,* (1997) described soil microbe and faunal diversity in Welsh soils, and while the soil types may differ, the message to enhance diversity is the same. This paper also described indicators that could be used to define soil "health" in an organic system.

Eason *et al.,* (1999) and Cook *et al.,* (1995) both described how management can impact on soil microbe and fungi populations and how this in turn can influence plant growth.

## *Trace Elements*

Condron *et al.,* (2000) presented a comparison of soil quality under conventional and organic management in New Zealand. One area of focus in the paper was on trace elements in soils under organic and conventional pasture and their effects on animal health. Trace element impacts on animal health were also mentioned in some of the more generic animal health papers described earlier. Other than this work, there was very little information on trace elements in soils under organic pastures.

## *Microbial Activities and Biomass*

Synthetic water soluble fertilizers are known to be detrimental to soil microorganisms and therefore to influence biological and physical soil characteristics negatively in the long term. Mader *et al.,* (1995) studied the effect different fertilization intensities on different crops have on soil microorganisms at different soil depths. They compared organic and conventional farming systems in Switzerland and reported that soil microbial biomass was significantly higher under the biodynamic system. Wood (1995) reported on studies in the UK, that showed an increase in earthworm populations with additions of manure; and comparisons of conventional and biodynamic farms in New Zealand showed that the biodynamically farmed soils had better structure, lower bulk density, higher organic matter content and respiration rates, and higher earthworm populations.

Pfiffner *et al.,* (1996) described a long-term trial (running since 1978) studying the effect of different farming systems (biodynamic, organic and conventional) on ground beetles. The number of species was consistently higher (193 %) in the biodynamic than in the conventional (100%) and organic (188%) plots. The number of species differed from 18–24 in biodynamic plots, compared to 19–22 in organic and 13–16 in conventional plots. In 1998 Pfiffner *et al.,* (1998) reported on a long-term trial into the effect of different farming systems (biodynamic, organic and conventional) on earthworm populations. The earthworm biomass and density, and the number of juveniles and earthworm species were significantly higher in the biological than the conventional or organic plots.

Ryan (1999) reviewed studies with regard to the question ‘Is an enhanced soil biological community a consistent feature of alternative agricultural systems?’ Studies that examined four groups of soil organisms, comparing the soil biological community in conventional, organic and biodynamic management system were reviewed, and a case study of biodynamic and conventional dairy farms in Australia included. Ryan’s conclusion was that the enhanced soil community found on the biodynamic farms relative to conventional neighbours should not be considered as a definitive feature of alternative agricultural systems, but rather as an effect of the higher input of organic matter.

Lytton-Hitchins *et al.,* (1994) came to the same conclusion after comparing the physical and chemical properties of biodynamically and conventionally managed pastures in NE Victoria, Australia. The more favourable properties found on the biodynamically managed soils are attributed to decreased grazing pressure, longer intervals between irrigations, reduced tractor traffic and intermittent applications of compost and hornmanure preparations.

Ryan *et al.,* undertook a glasshouse experiment with soil samples from 3 biodynamic (without conventional fertilizers for 17 years) and conventional (regular inputs of soluble P and N fertilizers) dairy pastures. Plant nutrient uptake was examined by assessing the response of white clover, perennial rye grass and indigenous VAM fungi to the addition of 4 levels of soluble P and N. Their findings indicated that the soils had not developed substantially different processes to enhance plant nutrient uptake. The experiments did not examine the response of plant nutrient uptake to non-water-soluble fertilizer, which might have produced different results.

Oberson *et al.,* (1995) studied the role of microbiological processes in organic P transformations in soils under conventional and organic (biological) farming systems during the 13$^{th}$ and 14$^{th}$ year of different cropping systems in the DOC (bio-Dynamic, bio-Organic, Conventional) long-term field experiments at Thervil, Switzerland. They found that soil ATP content was higher under the biological systems, resulting in greater amounts of P held in the microbial biomass. The activity of acid soil phosphatase was higher in biologically cultivated plots, indicating an increased potential to mineralize organically bound P in these soils. Organically bound P, especially the pool of microbial P, was greater in biologically than in conventionally cultivated soils.

Reganold *et al.,* (1995) summarize from various studies that biodynamic farming systems generally had better soil quality and, despite lower crop yields in comparison with their conventional counterparts, were just as economically viable on a per-hectare basis.

# Organic Pasture Systems

## *Pastures*

Compared with crop production systems, there is very little information available on organic pastures for dairy production. This is primarily due to the intensive, housed nature of animal production systems in Europe, where the majority of organic research is undertaken. There is, however, increased interest in the use of pasture as a feed source, particularly in the United Kingdom. Topics identified in the literature under the heading of organic pastures included composition, herbal leys, nutrient management, grazing management, fertilization, legume content and grassland management before conversion. New Zealand has a wealth of information on conventional pasture management and many of the theories behind this are applicable to organic systems. What is lacking in New Zealand is specific research on organic pasture systems and the effect that organic practices will have on pasture production, quality and composition and interactions with other components of the systems (e.g., animals, soils).

## *Permanent Pasture Composition*

There has been no published research carried out in New Zealand on the composition of pastures under organic management. Some research from overseas are applicable in New Zealand, however. A key factor highlighted in this literature is the use of legumes in pastures as a source of nitrogen. A difference between New Zealand and many European systems is that in Europe ryegrass/white clover leys are considered a fertility-building crop rather than permanent pastures. Le Gall *et al.,* (1997) described typical pastures in France under organic dairy/beef grazing and how to maintain desired sward composition. The pastures described in this paper are very similar to New Zealand pastures, and the information is therefore transferable. Frieben (1997) highlighted the impact that pre-conversion fertilization has on pasture composition under the organic system. Studying the stand composition and species diversity on permanent pastures on 7 organic farms in Germany and comparing these with conventionally managed grasslands, she found the number of species in organic grassland was greater than in conventional grassland. Cook *et al.,* (1995) described soil biodiversity and its interaction with grassland management, emphasizing the importance of balancing the whole system. In key research, van Elsen (2000) emphasized the importance of species diversity, in an organic farming system. Plant species diversity, genetic diversity within species, insect diversity and animal diversity are all important for an organic system to function efficiently. Padel *et al.,* (2000) reported on forage field measurements undertaken during conversion of dairy farms to organic production in the UK. Herbage growth fell by 15% during the first year of conversion, but by year 3 had recovered to 93% of pre-conversion values. The white clover content of the herbage increased substantially throughout transition, from less than 5% to over 30% by year 3. Colmenares *et al.,* (1999) observed the effects of the application of biodynamic preparations over a 3.5-year period on permanent grassland in Spain. The results indicated that the biodynamic preparations enhanced production and dry matter content.

## *Leys*

In international literature there is much discussion on the use of leys, which are more often than not ryegrass/white clover swards incorporated into a crop rotation. The main purpose of these leys is to increase soil fertility. Petterson *et al.,* (1998) collected samples of grass and clover swards from leys during one season on different Swedish farms converting to organic farming, to obtain a survey of general practical differences in the botanical and chemical composition of leys during such a conversion. The main difference of practical importance was a significantly higher percentage of clover in organically grown leys, and differences in botanical composition and with harvest times.

There is less discussion, however, about herbal leys, which are typically made up of a diverse range of species. Foster, (1988) published a key paper on this topic. It described research carried out on herbal pastures from 1850 to 1984. While this paper does not specifically discuss organic systems, much of the research described was carried out pre-synthetic fertiliser, and can therefore be applied to the organic system. Foster's paper described species and their specific attributes, different mixes commonly used, management, dry matter production and animal production from herbal pastures. The main body of work carried out in New Zealand on herbal leys was not under organic management as such, but under conditions of nil synthetic fertiliser and herbicide/pesticide application. Ruiz-Jerez *et al.,* (1991) described an experiment comparing production from a herbal ley sward with a low N and a high N ryegrass/white clover sward. This is a key paper on/for herbal ley production in New Zealand. Two subsequent papers (Ruiz-Jerez *et al*., 1995 and Ruiz-Jerez *et al*., 1994) described the nitrate leaching and denitrification, respectively, from the experiment discussed in Ruiz-Jerez *et al.,* (1991).

## *Pasture and Grazing Management*

Most of the conventional research carried out in New Zealand over the last 50 years on grazing management in particular would be applicable to organic pastoral systems. The key factor in a pastoral system is to utilise as fully as possible all pasture grown so that it can be converted into milk, regardless of whether a system is under conventional or organic management. Most of the international research on organic pasture/grazing management has been undertaken in the United Kingdom, with the Institute of Grassland and Environmental Research (IGER) being particularly active in this area. Stickland (1988) covered the topic of grassland management in an organic system and described species common in New Zealand. Watson and Philips (1997) looked at environmentally responsible management of grassland to avoid such problems as N leaching and erosion. Eriksen *et al.,* (1999) looked at N leaching that can be caused when permanent pastures are ploughed up, and Conacher and Conacher (1998) identified management practices that can prevent some of the negatives of organic farming, such as mining of soil nutrients and elements.

## *Pest and Disease Management*

While there is a vast amount of international research describing the specific treatment of a pest/disease, particularly in cropping systems, there was not much research (and no New Zealand research) dealing with pastures. A few generic papers have been identified that describe the importance of functional diversity in preventing pest and disease infestation of plant communities (including pastures and fodder crops). Finckh *et al.,* (2000) discussed why pests and disease are likely to occur and the management of their prevention. La Torre & Donnarumma, (1999) emphasized the importance of prevention in organic systems, and Hopkins & Feber, (1999) described the technique of maintaining a high pest predator population in field margins, again emphasizing the importance of biodiversity.

## *Weed Management*

An abundance of international literature was identified dealing with weed management in organic cropping systems. There was very little (and again no New Zealand specific research) particularly targeted at pastoral systems. A number of generic organic weed control papers have been identified (Leake, 2000; Christensen *et al*., 1999; Rasmussen & Ascard, 1994; Marshall, 1992; Stopes & Millington, 1991; Patriquin, 1988) that include methods such as tillage, timing of operations, sowing rates, cultivar selection, mulching, livestock grazing, composting, flame weeding and allelopathy for control of weeds.

### *Animal Management and Health*

There is a huge range of international literature in the area of animal management and health; however, it is not targeted specifically at pastoral systems but rather all organic dairy production systems. Again, no New Zealand-specific research was identified. The focus of much of the research was the use of management practices to maintain good animal health, and most of these good management techniques would be directly applicable to New Zealand pastoral dairy systems. Topics included dairy cow fertility (Reksen *et al*., 2000; Augstburger *et al*., 1988), mastitis (Hovi & Roderick, 2000; Olesen, 1996), animal nutrition (Ebbesvik, 1993), rearing of young stock, parasite control (UK Organic Livestock Research Group, 2000; Younie, 2000; Krutzinna *et al*., 1996) and general papers covering animal health and husbandry. The paper by Sundrum (2001) was a key paper as it critically reviewed literature on animal health, welfare and organic product quality. Various publications confirmed that animal health, represented by expenditure on veterinary costs or incidences of diseases, is generally significantly better on organic farms than on conventional farms (Perellin *et al.*, 1998; Olesen, 1996; Weller, 1996; Ebbesvik, 1994). Offerhaus *et al.,* (1993) and Ebbesvik, (1993) reported on better fertility on organically-managed dairy farms.

### *Farm Management*

Most of the papers described in earlier sections contain information on management of organic farm systems that may be useful to those converted or converting to organics. Austria Bundesanstalt fur alpenlandische Landwirtschaft Gumpenstein (2000) discusses managing high yielding cows and the effect of grassland management on milk production. MacNaeidhe (1992) and Younie *et al.,* (1988) looked at management problems when converting to organics, Anon (2000) focused on whole-farm system management, and Disenhaus *et al.,* (1999) looked at the role of extension in assisting managers. Again, there was no published research on this topic specific to New Zealand.

### *Milk Production Potential*

There was no published research undertaken in New Zealand on organic dairy production potentials, and it was very difficult to find any data relating to organic production potentials that could be directly transferred into the New Zealand situation. Organic farming systems in Europe tend to have much larger animals that are fed high energy concentrate diets and therefore have greater yield than New Zealand animals. Milk production levels from organic systems compared with conventional were varied. In Pabst, (1994) and Weber *et al.,* (1993) milk yield was lower on organic farms but in Jonsson (1996) was slightly higher. These contrasting results emphasize the overriding importance of good farm management on organic farm production potential.

### *Wider Environmental Issues*

With farm management, it is important to consider the impact of any agricultural system on the environment and this is particularly so under the organic philosophy of farming. Several research articles were identified dealing with the issue of organic production and its relationship with the environment. Eriksen *et al.,* (1999), Ruiz-Jerez *et al.,* (1995), Ruiz-Jerez *et al.,* (1994) and Watson *et al.,* (1989) looked at the denitrification and nitrogen leaching that can occur from permanent pastures and herbal leys. Watson and Philips (1997) described environmentally responsible grassland management techniques, and Cederberg (1998) described key environmental differences between an organic and conventional milk production system.

## Recommendations

The following questions, in relation to the New Zealand system of farming, are not answered by the current literature. Research in these areas needs to be undertaken for pastoral organic dairy farming to be economically, environmentally and socially sustainable in New Zealand.

- Soil quality under organic pasture management: Does organic management positively influence physical soil characteristics long term, e.g., the water-holding capacity of the soil in times of drought, or reduction of the damage occurring through animal treading on pasture in wet conditions?

- Pasture composition: Will pasture quality change under organic management? How? What composition dynamics are likely to occur during the conversion phase when conventional fertilisers are removed?

- Herbal leys: What is their value in New Zealand systems as an alternative forage (during drought, etc.)? What is their potential from an animal health perspective?

- Pasture/Soil Interactions: What are the key relationships? How is a healthy soil developed and maintained under intensive grazing pressure? How do soil/plant and animal interact? What is the role of trace elements in pasture production and animal health?

- Pasture systems: How much is actually grown in an organic system? How do organic dairy pastures need to be managed? Are grazing management techniques the same as on a conventional farm? How can a pasture system be managed so that it has minimal impact on the environment? How are pests, diseases and weeds specific to New Zealand controlled?

- Animal health: How do organic farms need to be managed to prevent diseases common in a pasture-based dairy production systems?

- Effluent: What are the effects of organic farm management on the wider environment? Does organic management with no input of water-soluble fertilizer and decreased stocking rates reduce the amount of detrimental nutrient leaching into surface and ground water?

- Evaluating the literature on research undertaken in Europe on the different treatments of slurry and the methods and timing of its application onto pasture – are some of these research findings applicable to New Zealand conditions?

These are a few of the questions that need to be answered, first to give farmers the confidence to convert to organic dairy production, and second to enable them to farm successfully and in a sustainable manner.

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# 4 ORGANIC FRUIT PRODUCTION IN NEW ZEALAND – A REVIEW OF UNDERSTOREY AND SOIL MANAGEMENT LITERATURE

## Introduction

A decade ago very little attention was given to research on organic fruit production in New Zealand or internationally. In this regard, the work of Daly and colleagues at the Winchmore apple orchard could be regarded as pioneering. This is reflected by the fact that their work is one of the principal sources of published literature on understorey and soil management for organic apple production. Other research is being conducted, at the Louis Bolk Institute in the Netherlands, but much of this material has not been published in English. There is relatively little, if any, literature on organic systems of other temperate and sub-tropical fruit crops.

Because of this, this review is far from comprehensive and does not solely rely on findings from organic research programmes. Within the scope of this study as wide a net as possible has been cast to draw together relevant literature, not all of which has been peer reviewed. As a starting point, a review of what is already known in New Zealand is provided. This is followed by a review of literature from international sources, sourced primarily from abstracting databases and the internet. It is hoped that as this material is read, a reasonable picture of what is known about organic soil management in orchard environments will emerge for the reader, and questions may begin to arise about what is not known. A final section is provided in which the various threads are drawn together to develop a clearer picture of important gaps in knowledge that need to be addressed in a New Zealand context.

## New Zealand Literature on Understorey and Soil Management

There is very little published literature on orchard understorey and soil management in New Zealand. The most relevant material is from the Winchmore apple orchard study, which began in 1989. Key papers are Daly, (1994) and Marsh *et al.,* (1996). Other useful papers are Goh *et al.,* (1994) and Marsh *et al*., (1994).

Daly (1994) indicated that an important reason for choosing the Winchmore site was that it was an existing 3-year old orchard, (containing Royal Gala, Red Delicious, Braeburn and Fuji), and thus changes through the organic conversion process were able to be examined. While conversion is a more difficult option than designing an organic system from the outset, it is the most common scenario faced by potential organic producers. Three separate herbage understorey treatments were examined. The red clover understorey led to the best tree growth and highest tree nitrogen in the early years of conversion, but showed lack of persistence after 3 years (Daly, 1994). With its persistence, positive tree growth and nutrition effects, the herb ley was found to be the most promising. Mowing management and mulching also had very positive effects. No decline of soil nutrient reserves was observed over the initial 4 years, which was attributed to enhanced microbial activity and increased earthworm numbers. Fruit quality was good with all understorey treatments, with no nutrition or storage disorders.

Marsh *et al.,* (1996) examined the effects of understorey treatments in more detail, and concluded that tree nutrition will be affected by choice of understorey species and management (e.g., mowing vs mulching), but the overall effects on tree growth, yield and storage disorders showed minimal differences after 3 years. Mulching (with mown herbage and pea straw) showed a number of benefits, including increased soil nutrients (C, N, K, Mg, Ca), increased leaf N and K, increased pH, and increased tree growth and fruit yields. The greatest difficulty faced at the Winchmore site, and still prevalent with organic apple production in New Zealand, was vulnerability to disease infection.

In a separate study, at Appleby, Marsh *et al.,* (1994) examined the effects on the quality of Fuji apples of managing nitrogen levels with different understorey management. They found more highly coloured fruit and advanced fruit maturity with a grassed understorey, which compensated for lower yields under this regime through a higher export pack-out.

Of interest is a mulching trial in a Hawke's Bay apple orchard by Hartley *et al.,* (1994), who found that straw mulch, in particular, was beneficial in terms of weed control and reducing diurnal fluctuations in soil temperature.

Goh *et al.,* (1999) evaluated the effects of different production systems (organic, integrated and conventional) on the quality and quantity of soil organic matter in the soil, and identified sensitive indicators. They found no significant differences between commercial and experimental orchards. Sensitive indicators of differences between different production systems included the microbial biomass C (BC) and the ratio of BC to total carbon (TC).

With a shift to integrated fruit production (IFP) by the pipfruit industry and an increasing number of organic producers, there is an increased interest in understorey management. A Sustainable Farming Fund project, being implemented through the Focus Orchard programme, aims to develop an understorey management strategy for the pipfruit industry, including: selection of appropriate species, soil health implications, information on likely effects on tree growth and fruit development. As a precursor to this project, a survey of current understorey management practices was made (NZ Pipfruit Ltd, 2001). Tree strip management by surveyed organic growers and some IFP growers includes mulching (with mown grass, bark, straw) or use of herb leys and rye/clover. Orchard sward practices included use of herb leys, clover, spread of mulched prunings, leaving the sward to grow.

Surprisingly, it appears that there has been no research done on organic soil and understorey management for kiwifruit in New Zealand. A thorough search of the HortNet web site, which contains comprehensive information from a diversity of sources, yielded one reference (Stowell, 2000), which related to maintenance of soil fertility and yields for organic kiwifruit production.

There is no published literature on organic soil and understorey management of citrus in New Zealand, although there has been some work done on nitrogen nutrition (Mooney *et al.*, 1997). For mature trees (5 years or older) a strong spring flush is desirable for commercial production. This is best managed by autumn applications of nitrogen, with a recommended application rate of 3–4 tonnes per hectare from organic sources.

No relevant New Zealand literature was found for avocados or stonefruit. The New Zealand Avocado Industry Council is in the process of implementing an understorey management project, supported by Agmardt, although this is not specifically focussed on organic production. There is also a mulching trial in place at an organic orchard in the Bay of Plenty, established by Dr Ben Faber, a farm advisor from California, USA. A principal focus for this work is phytophthora control.

### *Summary*

The Winchmore study established a valuable knowledge base for organic understorey and soil management in New Zealand apple orchards. The pipfruit industry currently has a strong impetus towards organic production, and there is increased research taking place that is of relevance to organic pipfruit growers. Much of the current research is focussed on disease problems, particularly blackspot. An understanding of the link between organic soil management, nutrient dynamics, and pest and disease management has yet to be developed. Aside from the research on pipfruit, there has been no significant research of relevance to organic systems under other fruit production systems.

Useful New Zealand websites include:

- the HortNet site, maintained by HortResearch: http://www.hortnet.co.nz;
- use the search engine to identify "organic" references;
- the New Zealand Pipfruit Limited site: http://www.nzpipfruit.co.nz (under development).

## International Literature on Understorey and Soil Management

The principal sources of international literature were the internet and searchable databases. Two important sources of information are the Henry Doubleday Research Association (HDRA) in the UK and the Louis Bolk Institute (LBI) in the Netherlands. For a more practical and relatively generalised focus, the Appropriate Technology Transfer for Rural Areas (ATTRA) programme, in the USA, is a good source of information.

Much of the available literature focuses on apple production. Material from HDRA and LBI is strongly focussed on apples, and is reviewed separately. The remainder of the literature, including relevant information gleaned from ATTRA publications, is organised thematically, rather than by crop, as there are common principals and practices relevant to a variety of perennial fruit crops. Apart from apples, literature relating to avocados, citrus, kiwifruit and stonefruit was reviewed. In some cases, such as with information relevant to phytophthera control in avocados, separate sections are justified.

### *The Henry Doubleday Research Association (HDRA) and Louis Bolk Institute (LBI)*

The HDRA received funding from the Ministry of Agriculture, Fisheries and Food for a year-long study on organic fruit production (Bevan & Lennartsson, 1999). The main aim of this project was "to collect existing information on organic fruit production from growers, researchers and advisors from both the UK and overseas." The 128-page report produced is focussed principally on apples and strawberry production, largely because there was more information for these crops, and to a lesser degree on pears, raspberry, currant and gooseberry production. The principal sources of information for the literature review of apples were the work of Daly, Marsh and colleagues in New Zealand, and the work of Bloksma and colleagues at the Louis Bolk Institute (LBI) in the Netherlands. A strong theme in this review is the issue of providing adequate and balanced nutrition to apple trees. Successful organic soil management is related to understanding and managing the soil processes. The management of the understorey for nutrient supply to the trees also has to be balanced against competition in the treeline for nutrients and water. Under temperate European conditions the availability of adequate nitrogen in spring, when soil temperatures and microbial activity are low, is very important for good fruit set and yield. The mineralization and immobilization of nutrients by microbial activity in the soil, the principal source of nutrient supply in a well-balanced organic system, is a principal focus of a detailed report on "Soil management in organic fruit cultivation" by Bloksma (1996).

The LBI agriculture department was established in 1987. Their research is conducted on-farm, and the research focus is developed in a participatory manner with growers. A significant amount of research on organic apple production has been carried out over the last decade but the bulk of the research findings have been published in Dutch, with relatively little available in English. The above-mentioned report (Bloksma, 1996), which has recently been updated and revised, has not been translated to English although it contains valuable information. Recent annual reports (Bloksma & Jansonius, 1999, 2000) in English are available from the LBI website and provide a useful overview of current research, including recent research findings. While the specific questions being addressed by LBI may not be directly relevant to New Zealand conditions, their holistic research approach is. The LBI organic systems programme aims to design "a coherent package of measures, which integrates weed control, fertilisation, cover crops, growth regulation and ripening" (Bloksma & Jansonius, 1999). A current research focus is on various ground-cover treatments at the tree strip. They have examined four different strategies:

- a permanent cover crop of white pasture clover (*Trifolium repens*) that is regularly mowed. This strategy is considered most suitable for fertile pastures, older trees and where irrigation is available;

- the sowing of a late summer cover crop that is mechanically removed in spring. This strategy is considered most suitable for younger trees, where there is greater light penetration to the tree strip and where growth inhibition in late summer will benefit fruit maturation. Species considered the most suitable are: fodder radish, turnip, Phacelia and possibly winter rye;

- the "sandwich system", developed in Switzerland, which involves planting a narrow 30cm strip between the trees and maintaining a cultivated strip on either side of this;

- the establishment of clover "islands" around the tree while keeping the remainder of the tree strip free of growth. This system is being evaluated on an orchard where no irrigation is available.

From a nutrient management point of view, a principal aim of these strategies is to optimise nutrient availability to the tree, particularly nitrogen. For example, the sowing of late summer cover crop is seen as a good strategy for transferring soil nitrogen from late summer/autumn to the following spring.

## *Understorey management*

Ames & Kuepper (2000) provide an overview of issues relevant to organic production of temperate zone fruits. Amongst other things they provide an overview of orchard floor management and mulching. The benefits of ground covers to soil and tree nutrition and for pest control, are discussed. General guidelines for mulching are also provided, with established benefits including: weed control; enhanced soil aggregation and water availability; moderation of soil temperatures; reduction of plant stress; and greater availability of major nutrients. These authors also mention the benefits of improved soil organic matter in reduced susceptibility to disease.

Mitham, (1999) reports on a presentation by David Granatstein, coordinator of the Center for Sustaining Agriculture and Natural Resources at Washington State University who talked about the importance of shifting from the trading of inputs, which often characterises orchards and farms in the early years of conversion to organics, to the need to change management practices. The rest of the article discusses the merits of using cover crops in the orchard environment, to replenish soil nutrients and manage tree vigour, control weeds and orchard pests, and reduce erosion. The importance of matching a particular cover crop to needs, aimed at achieving best practices for a particular farm, is discussed.

Warner, (1998) reports on a presentation by Dr Robert Stevens, a soil scientist with Washington State University. Stevens talks about the importance of allowing soil to develop a balance over time. In the context of balancing nutrients, he comments that there is a very small pool of nutrients being balanced, and thus even small doses of fertilizer can cause big swings. The comment is made that "growers should be concerned about movement of nutrients and whether the orchard contributes to leaching into groundwater". It is significant that these comments were not specifically directed at organic production, indicating that there is an increasing awareness of the importance of developing a balanced, healthy, environment for sustainable fruit production.

## *Use of cover crops and nutrient management*

Earles *et al.,* (1999) provide several grower case studies, including a Maryland organic apple grower who uses a variety of products to boost soil fertility, including: green sand; rock phosphate; compost from beef manure and leaf litter, fish meal and pelletized poultry litter. He uses a cover crop of clover and Companion grass (a cross between dwarf fescue and rye). Schenk and Veijer (1996) experimented with different cover crops for apples and found turnips (sown in mid summer) gave highest soil N reserves, followed by a mixture of summer cabbage and Phacelia. Mulching with organic materials in a young apple orchard had a number of benefits, including well-balanced temperatures, and low nitrate levels during the growing period. A late summer cover crop, sown in the cultivated strips, reduced nitrate concentrations in soil water (Himmelsbach *et al.*, 1995). In a 14-year trial, frequent cutting and mulching of a grass-legume cover crop gave the highest yield, increased soil organic matter and nutrients and moderated upper soil temperature during the summer (Shabanova, 1985). Heller & Weibel, (1997) provide an account of plant nutrition and fertilization needs in IFP and organic apple production systems in Switzerland.

Ben-Ya, (1995) found higher avocado yields with organic manure, compared with N fertilizer, while Garcia *et al.* (1989) examined the soil and plant nutrition status of a biodynamic avocado plantation (compared with a conventional system), where they found higher levels of pH, OM, available P, Ca, Mg and K in the biodynamic system. Jaime *et al.* (1994) found that greater tree size and fruit yield was realised with mulching in an avocado orchard, but soil cultivation and permanent swards were preferred because of smaller tree size, which made them more manageable.

Dou & Alva, (1998) found that citrus leaf litter makes an important contribution to available N in the soil. In another study on citrus nutrient management, Calabrese, (1992) found that N application (based on leaf analysis) was being overemphasized and that low soil organic matter was becoming a problem.

Celano *et al.,* (1997, 1998) recommended sowing crops in autumn to take up residual N from soil and incorporating them into the soil in spring at the time of peach bloom, ensuring sufficient supply when demand from trees was greatest (1 month after full bloom). Green manured soil showed higher microbial and soluble C. Vitanova (1999) found winter fodder peas and pea-rye mixtures to be suitable for green manuring on Stanley plum trees. Pre-plant compost application and mulching of the soil surface had very positive effects on cumulative yields in an apricot orchard. Compost increased cation exchange and water holding capacity of the soil (Kotze & Joubert, 1992).

Different cover crops in a 9-year old vineyard (cv Merlot) were found to reduce excessive growth and cropping, and also the incidence of Botrytis infection (Sicher *et al*., 1995).

In a tropical environment, use of nitrogen-fixing species for hedgerows and mulching is a common technique for soil improvement, particularly in degraded sloping land environments. Trials with Jackfruit in Hawaii showed improvements in soil K, N and pH (Elevitch *et al.*, 1998).

## *Mulching*

The benefits of mulching are now widely recognised. A large number of studies have evaluated a range of mulching practices. Key findings from these are summarised:

- Pine (as well as oak) bark used as a mulch suppresses weed growth, enhances fruit tree development, gives higher yields and fruit quality (Domange & Thomas, 1994; Spring, 1993; Mantinger & Gasser, 1993; Niggli *et al.*, 1989);

- Mulches reduce diurnal fluctuations in soil temperature (Hartley *et al.*, 1994; Himmelsbach *et al.*, 1995);

- Mulches improve water retention in the soil (Buban *et al.*, 1995; Himmelsbach *et al.*, 1995; Merwin *et al.*, 1994; Nath & Sarma, 1992);

- Mulches give lower nitrate levels (Himmelsbach *et al.*, 1995; Marks, 1993; Niggli *et al.*, 1989) but this has no consistent effect on crop N status (Marks, 1993; Niggli *et al.*, 1989);

- Mulches (bark and grass) give a more even N balance through the year, a better water balance and improved soil surface texture (Nedwed, 1991; Kruger & Kuck, 1990). Grass mulch was useful for regulating nutrient supply to the trees (Nedwed, 1991);

- Soil microbiological life is enhanced, but in varying ways, by mulching with straw, livestock manure and pine bark (Buban *et al.*, 1995);
- Green manuring improves soil structure, fertility and apple productivity (Klad *et al.*, 1992).

## *Phytophthora control in avocados*

With respect to the benefits of various organic soil treatments for phytophthora, most studies showed benefits from mulching or use of ground covers. Mans and Hattingh (1992) experimented with three permanent ground covers (Arachis glabrata, Polygonum capitatum, Lippia canescens [Phyla nodiflora]) in an avocado orchard. While the latter species showed the greatest potential because of relatively rapid growth rate, it competed for N. A. glabrata increased N content of leaves. There was no incidence of Phytophthora at time of planting or 1 year later. Cow manure, alone or in combination with lucerne straw-resulted in better control of P. cinnamoni and higher root growth and yield (Cortes-Flores *et al.*, 1993). Duvenhage *et al.,* (1993) applied various organic soil amendments to Fuerte trees recovering from root rot. Condition declined during the 3rd and 4th years of the trial, attributed to drought stress, but improved with use of a leguminous cover crop or a lucerne straw mulch. Rosas-Romero *et al.,* (1986) found best phytophthora control with lucerne straw alone or in combination with cow dung. Ames and Kuepper, (2000) use the example of phytophthora control of avocado, citing work from Australia where liming and cover crops are used in combination with applications of chicken manure, cereal straw, weed residues and other materials.

Dr Ben Faber, made available a detailed report of a California study on use of yard trimmings and compost for phytophthora control on citrus and avocado (Menge *et al.*, 1999). Their findings indicated significant benefits to avocados from the use of mulch. Benefits included increased root growth, and in two out of four groves they observed improved growth, yield, or appearance as a result of mulch application. Microbial numbers were found to increase in the vicinity of the mulch, including two enzymes, cellulase and laminarinase, which dissolve the hyphae of *Phytophthora cinnamomi*. These effects were only noted in the surface soil layers, not deeper, but were beneficial because of the predominantly surface rooting habit of avocados.

## *Plant nutrition and disease*

In the case of a Maryland organic apple grower, discussed by Earles *et al.,* (1999), the grower's experience is that there is a correlation between high nitrogen availability and high disease pressure. As a result, the grower deliberately under-uses nitrogen and has noticed an increase in yield. Earles *et al.,* (1999) also discuss briefly the disease-suppressing effects of composts, which are discussed in more detail by Granatstein (1998).

Warner, (1996) reports on a University of California study that found that excess nitrogen can make peach trees more susceptible to pests and diseases, reduce red colour on the fruit, and increase nitrate leaching to ground water.

Ground-cover management is very important for N regulation in vines, e.g., excess N during berry maturation can lead to greater incidence of Botrytis and greater must acidity (Maigre & Murisier, 1991).

## *Fruit quality*

Grass cover gives lower fruit yields (Hornig & Bunemann, 1995; Mage & Skogerbo, 1992) and improved fruit colour and acid content (Hornig & Bunemann, 1995).

## *Soil quality indicators*

Swezey *et al.,* (1998) examined changes during conversion of an apple orchard to certified organic management. Soil bulk density and water-holding capacity were good indicators of physical soil changes. Sensitive indicators of soil biological changes were the potentially mineralizable nitrogen and microbial biomass-C. Increased earthworm biomass and abundance were observed in the third year.

## *System design*

Ingels, (1992) outlines a range of factors important for development of sustainable grape growing, including site and cultivar selection, crop diversity, soil and nutrient management, reduction of off-farm inputs.

Granatstein, (2001) provides a useful review of orchard understorey management. In his introduction he discusses what is meant by *sustainable* as a concept, which in his view encompasses three parts: economically viable; environmentally sound; and socially responsible. He then extends this to highlight changes in orchard management, which are increasingly encompass these three parts. The discussion is further developed to highlight the need for conscious design and management of systems, citing the work of Stuart Hill (in MacRae *et al.*, 1990), who identified three strategies that represent degrees of sustainability. The first can be equated to the introduction of IPM strategies, focussed on improving efficiency of existing systems. The second involves input substitution, which normally occurs in the early stages of conversion to organics. The third involves conscious design, or re-design, of the agro-ecosystem. Redesign of the orchard understorey is placed in the last category. The various functions of the understorey and design issues are discussed, and topics covered include: cover crops; weed control and mulches; soil fertility; soil health. Granatstein, (2001) concludes that "more research is needed on both the biology of individual components and the ecology of the system so components can be combined for optimal benefit".

In many developing countries, diverse agroecosystems are an integral part of traditional agricultural practices. There systems provide multiple benefits — to the environment, people and local economies. For example, studies by Grewal *et al.,* (1992) and Neugebauer, (1990) focussed on the benefits of two different agroforestry systems, one in northern India, the other in Mexico. These ecologically diverse systems, which included citrus and other fruit trees, showed considerable benefits to the environment and local economies. While such systems are not directly transferable to New Zealand, they do provide important information on the benefits of ecological complexity in agroecosystem design.

### *Summary*

The preceding review was drawn from international literature with a specific focus on soil-plant-animal systems research relating to perennial fruit production. As with the New Zealand situation, overseas research has predominantly focused on organic apple production. Important issues emerging from this review are: the importance of understanding and managing nutrient flows in the orchard system; linkages between nutrient management and disease pressure; and the importance of developing a more holistic approach to research on organic soil and understorey management in orchard systems.

Useful international websites:

- appropriate Technology Transfer for Rural Areas (ATTRA) horticulture page http://www.attra.org/attra-pub/horticulture.html
- the Good Fruit Grower magazine http://www.goodfruit.com/core.html
- there are a number of articles on organic fruit production, available in back copies that are available on-line;
- the Louis Bolk Institute http://www.louisbolk.nl/
- The Henry Doubleday Research Association http://www.hdra.org.uk/

Other useful links can be found in the reference list.

## What Are the Gaps in Knowledge that Need to be Addressed in New Zealand?

In his introduction, Daly (1994) explained that conversion rather than system design is likely to be the most common situation faced by growers. This was an important rationale for using an already established orchard for their research. Many of the benefits of this research are now being realised, with significant numbers of apple growers successfully converting to organic production in New Zealand. However, those who have converted face on-going challenges, particularly with disease control. There is evidence to suggest that good organic soil management can lead to a reduction in disease problems as indicated, for example, by the observed link between overuse of nitrogen and disease problems. The greatest difficulty is that specific soil management solutions to widespread problems, such as blackspot or phytophthora, cannot necessarily be prescribed and do not wholly lie with the soil. Many factors play a role, not least the design of the orchard.

This is where the greatest challenge lies, as identified by Hill (cited by Granatstein, 2001) to move towards re-thinking the orchard system in a holistic framework. Very little of the material provided in the preceding sections has been gathered from such a framework, and for this reason provides only fragments of a complete picture. What, therefore, are some important gaps that need to be addressed?

- There is a need for a better understanding of nutrient flows in organic fruit production systems, for different crops and regions in New Zealand, and their link to tree health and vigour and fruit quality and yield.

- What understorey and soil management strategies work best for different parts of New Zealand and different production systems? Some useful work is beginning in this area, but it is not specifically focused on organic production systems.

- What are the optimal nutrient, soil, understorey and pest and disease management strategies in dynamic orchard environments where there are multiple interactions between these factors and a range of other factors, such as planting density, choice of cultivars or varieties, local climate and orchard microclimate, and orchard biodiversity (e.g., through planned diversification of shelter trees)?

These three general areas of research lead to increasing levels of complexity, and it is unlikely that answers will readily be found through short-term research programmes. In organic systems the solutions to problems are ultimately site and producer based. Many important changes in the system are likely to occur over longer-term ecological time horizons. This suggests the need for research that has the active involvement of producers, involves quantitative and qualitative approaches, and is focussed on understanding the dynamic and evolving nature of organic orchard systems, of which soil and understorey management is a very important component.

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# 5 RESEARCH IN BIODYNAMIC AGRICULTURE

## Introduction

The principles of Biodynamic Agriculture were presented by Dr R. Steiner, an Austrian scientist and philosopher in 1924 at the request of farmers who were looking for alternatives to conventional agriculture. They were concerned about the decrease of soil fertility, and the decline in both animal health and in seed and food quality that was becoming evident at that time. A series of eight lectures by Steiner, known as the Agricultural Course, became the foundation for the biodynamic method of agriculture (Steiner, 1924).

In New Zealand, biodynamic methods were first used in 1928 in Havelock North. The Bio Dynamic Association in N.Z. Inc. currently has over 800 members and about 40 Demeter-certified farms. Demeter is the sole internationally recognized and used standard for certification of biodynamic farms and produce. The aims of biodynamic agriculture are to restore and maintain the vitality and living fertility of soils, and in doing so, produce foods of the highest nutritional quality.

At the centre of the biodynamic method and therefore of research on biodynamic agriculture are the concept of the farm as a unique individuality, the two field-spray preparations (horn-manure, also known as preparation 500 and horn-silica, also known as preparation 501) and the six compost preparations (known as preparations 502–507). For details of these preparations see Koepf *et al.,* (1976).

Early biodynamic research in Europe was focused on finding proof that biodynamic preparations have a measurable effect. By the end of the 1980s, the focus of research had shifted to examining how the preparations worked in relation to varying farm ecosystems. Since then research has become more focused on understanding the farm individuality.

A further uniquely biodynamic method, and one that has been a source of contention, is the ashing of weeds and pests. As this method requires a highly integrated level of knowledge of astronomy and biology it is beyond the scope of this report. Interested readers are referred to the Biodynamic Research Institute, Darmstadt branch, Bad Vilbel, Germany.

Soon after his Agricultural Course, Steiner (June 1924) emphasised the importance of making a direct link between research and practice, so that the empirical knowledge of the farmer and the scientific knowledge of a team of disciplinary scientists could assist each other. He also discussed the importance of supporting the farmer by placing scientific knowledge in the context of farm ecosystems. This approach is consistent with participatory research methods now widely used in developing countries and finding increasing application in Europe, North America, and New Zealand.

## Research Approaches

In biodynamic agriculture one is confronted with concepts of terrestrial and cosmic origin, polarities, and questions of vitality and nutritional quality. The pioneering biodynamic researchers, in particular Pfeiffer and Kolisko, found conventional research methods were not always applicable and asked Steiner for advice, which led to the development of new and complementary research methods. Some of the most important biodynamic research methods, that have evolved from this early work, are outlined below.

### *Pictorial imaging methods*

Amongst other things, Pfeiffer and Kolisko tested measurable substances as well as highly diluted and or potentised substances and their effects on plant and animal with newly developed pictorial imaging methods (Pfeiffer,1939 and Kolisko, 1939, 1978). This work has been developed and refined by other researchers.

The starting point for this method is that formative forces of a living organism or system are recognisable in each part of the whole. Pictorial imaging methods make these formative forces visible in a picture and can be applied in the following ways:

- sensitive copper crystallisation picture, for example, from a drop of blood or plant extract;
- radial chromatogram from soil moisture;
- ascending chromatogram from plant extract;
- degradation/decomposition picture from raw food products;
- drop picture from water.

These methods are nowadays widely applied in combination with other complementary research methods and conventional methods, in biodynamic research (especially in the improvement of product and food quality) and areas such as medical diagnostics. Pictorial imaging techniques require training and experience before a picture can be read with accuracy. Dr Ursula Balzer-Graf from the Swiss institute Forschungsinstitut for Vitalqualitat has given this method a scientific base.

In a recent study, Anderson (2001) looked at the following methodological and experimental aspects of the crystallization method: crystallization chamber techniques, morphological features applicable for visual evaluation of biocrystallograms, computerized image analysis, application of the method in connection with different crop samples, and application of the method in connection with freezing processes of crop samples.

## *Goethean phenomenology*

The idea of a phenomenological approach was introduced by Goethe (1749–1832) and extended by Steiner. Through regular observation of the living plant, animal or other organism in all stages of growth, inner and outer pictures of its processes of movement and changes of form are developed. Bockemuhl (1977, 1985) developed this into a rational method to research the development of plants and their nutritional and medical properties.

This method is used extensively in research work on the application of biodynamic preparations, for example in the work of Bisterbosch (1994) on lettuce. Biographical sequencing of plant growth, for example in leaf series of fruit trees, can help orchardists and scientists evaluate and improve cultivation measures (Bloksma, 2000). The method is beneficial for forming hypotheses, and the synthesis of different parameters such as the relationships between soil, crop and animal. These relationships can then be considered for the farm or eco-system as a whole (LBI, 1998). The phenomenological approach can also be applied directly at the farm landscape level (see for example, Vereijken *et al.*, (1997)).

## *Long-term field trials*

The focus of biodynamic research on life processes requires long-term field trials of a minimum of 4 years to be held in different regional locations. A recent example is the Long Term Fertilization trial, supported by the European Commission, over a period of 7 years in Germany, Switzerland and Sweden, in which seven institutes participated (Raupp, 1999).

Gardner, (1997) discusses the ideas of Steiner for the setting up of test plots on the farm. Statistical models have been designed to exclude unpredictable environmental influences from the investigated variables. The Goethean phenomenological method plays an important role in the synthesis of different parameters in field trials.

## *Food quality*

Early organic and biodynamic research looked at differences in quality of products from conventional and organic agriculture. Research overseas has since entered a new phase aimed at:

- improvement of production methods based on the three criteria of organic production, i.e., semi-closed production cycles, natural self regulation, and agro-biodiversity;

- improvement of the vital quality of seed varieties, food products and food processing;

- investigation of the links between product quality and consumer health, in particular the influence of vital quality on certain life processes in human beings.

> In traditional science it is assumed that the nutritional or health value of food results from a measurable composition of substance only. Limiting ones point of view to these material aspects misses the fact that food from plants and animals are also the result of the integral organising activity of growing living things (Balzer-Graf, 1999).

Huber (IFOAM, 1999) defines quality by:

- the product's form;
- the quality of life processes;
- the analysis of its nutrients and other substances;
- the state of integration of its vegetative and generative processes.

The vital quality of a product, eventually determined by a complex of life processes, plays an important role in the consumer's perception of the value of food in relation to personal health.

New research aimed at adequate and precise assessment of the vital quality of products is under development. The Louis Bolk Institute in the Netherlands developed the concept of vital quality as determined by a complex of life processes at three levels: a) growth, b) differentiation or ripening, c) integration. In their multidisciplinary research project "Elstar", these three levels were examined in trials and tests on the growth, structure and coherence of apples (LBI, 2001).

The phenomenological method, the pictorial imaging methods and the lesser known biophoton measuring play a central role in research on food quality. Data resulting from the work with these methods are complemented by a series of other tests that include the following parameters:

- biochemical: respiration, enzyme activities, aroma patterns;
- chemical: free amino acids, Vitamin C, sugar, nitrate content, pollutants;
- physical: tissue strength;
- microbiological/biochemical: storage and intensity of microbial attack, dry matter loss, $CO_2$ development and darkening in degradation tests.

The advantages and disadvantages of the degradation tests have been discussed by Raupp (1998).

Parameters have also been set for consumer panel tests on taste, colour and smell, for shelf-life trials with retailers, and for trials on food preparation and food handling by chefs and bakers. Comparative trials of biodynamic and other food fed to animals have been studied by Gutknecht (1995).

A new International Network for Food, Quality and Health has recently been set up (m.northolt@louisbolk.nl). A training course on pictorial imaging methods for scientists is offered by the Forschungsinstitut fur Vitalqualitat (ursula.balzer@fiv.ch).

### *Farm participatory research model*

The requirement for the biodynamic farm to form a semi-closed system with a high degree of self-sufficiency and low dependency on input from outside the farm system has led to the development of farmer participatory research methods. The questions and experiences of the farmer form the basis of the research, allowing a symbiosis of scientific knowledge and empirical knowledge to take place (Baars, 1998, 2000). Results from all trials and tests are judged in the context of the farm as a living organism and as an individuality with its own characteristics of soil, climate, location, history, management style of the farmer, and economic possibilities.

## Research Findings Relating to the Biodynamic Preparations

This section provides an overview of research on the field-spray preparations from the pioneering phase of biodynamic agriculture through to a more mature phase. The latter has focused on gaining an increased understanding of the preparations through application of a combination of analytical and new research methods in the context of the farm ecosystem. Findings from recent research on the compost preparations are also presented.

### *Hornmanure and hornsilica preparations*

This review is based mainly on the publication of Lammerts van Bueren and Beekman-de Jonge, (1995) on the experiences, research and vision development on the use of the hornmanure preparation (field-spray preparation 500) and the hornsilica preparation (field-spray preparation 501) over 70–year timeframe. There is no translation of this publication from the Dutch. See also Goldstein, (2000). Lammerts van Bueren and de Jonge (1995) identify three development periods within this timeframe.

In the **first period,** from 1924 till the end of the '50s, the field-spray preparations were reported to give positive results when used in conjunction with the compost preparations. A series of publications suggest that there is a 20–30% increase in yield from use of the field-sprays (Voegele 1930,1937; Lippert 1931, 1933, 1938; Pfeiffer 1937). Pioneering research in the first half of this period was driven by enthusiasm and confidence in the preparations. Towards the '50s research developed more scientific rigour. Pictorial imaging methods were developed as a complement to conventional analytical approaches. Pfeiffer (1948) undertook chemical analysis, bacteria counts, and spectographic analyses of the preparations before and after fermentation in the earth. These tests provide rather amazing analytical data on the preparations and their bacteria-affecting properties. These tests have been repeated in the microbiological research of Dewes in the period 1983–1990.

In the **second period,** from the ‘50s until the end of the ‘80s, the main aim was to establish the effects of the preparations by scientific investigation. The research focused on various scientifically recognised chemical and analytical parameters as measurements for qualitative and quantitative effects. The results obtained could not always be repeated in subsequent experiments in different conditions of soil, climate or landscape.

In the **third period**, from the ‘80s onwards, emphases shifted to the restricting and stimulating effects of the two field-spray preparations on the development of crop processes in relation to varying agro-ecosystems.

De Vries, (1988) reported a balanced development of grass in spring and a stimulation of grass growth in autumn after applying the field-sprays 500 and 501. Von Mackensen, (1994) studied the effects of the preparations on strawberries and reported a rich setting of fruit, good aroma and fungus free growth, 30% higher yield, and 8–10 days earlier harvest when the hornsilica preparation was sprayed after harvest of the last crop and not in spring. He discussed the polar effects of this preparation as related to environmental factors of soil, light intensity and moisture. By stimulating one phase in the plants growth one can help the polar opposite phase to reach its full potential (Von Mackensen, 1994). Bloksma, (1995) found that young apple trees in pots in a nursery showed more balanced growth and developed less side branches if the preparations 500 and 501 were applied.

Research and practice show that the field-spray preparations positively influence soil processes such as levelling the pH, and optimising mineralisation, humification, germination and rootgrowth (Lammerts van Bueren *et al.*, 1955).

Work with the hornsilica preparation indicates that the preparation particularly stimulates those plant processes related to warmth and light, such as assimilation, ripening, shelf life and aroma. This is expressed particularly in the lowering of nitrate content and the increasing dry matter and sugar. Both preparations appear to regulate crops in such a way that plants are less susceptible to diseases and pests and have a longer shelf-life (Abele,1987; Lammerts van Bueren *et al*., 1988).

Application of both preparations may lead to a more integrated development of the crop plant to reach its full potential and provide corresponding quality improvements. The crop actively utilised the environment for its own development rather than submitting to the environment (Mansvelt, 1982). Application of the preparations creates conditions for a sound arrangement of life processes in an ecosystem. Koenig (1991, 1993) summarized the three principal effects of the preparations as normalisating, compensating and stimulating.

## *Complementarity of the field-spray preparations and the compost preparations*

Kotchi, (1980) found that field-spray preparations worked best if biodynamic compost had been applied. Wistinghausen (1984) confirmed this. This research shows the importance of an integrated approach to biodynamics; application of only some biodynamic preparations may give an unbalanced effect.

## *Use of horns*

Brinton, (1986) concluded that the bigger the weight:volume ratio of the horn used in making the field-spray preparations, the better the quality of the preparation. Big horns of bulls (which do not have rings) give a low quality of hornmanure. Dewes, (1983) found that hornmanure from a good horn contained microflora similar to those found in worm-castings, but these were not evident in hornmanure made in an imitation horn. Brinton (1986,1994) distinguished good quality hornmanure from low quality hornmanure by less rotting, an agreeable smell and less nitrogen loss. Goldstein and Koepf (1982) worked on quality control for preparations. They recommended their results needed further verification through field trials.

## *Frequency of applications*

Where field-spray preparations are applied with increasing frequency, there is often an increasing effect which is not always positive. Effects may be negative; apparent in the dehydrogenase activity of soil microorganisms (Dewes and Ahrens, 1989). Bisterbosch (1994) found in her research on lettuce, which included extensive phenomenological observations and food tests, that application of preparations 500 and 501 more than once during the growth season positively affected product quality. She concluded that the plants were more healthy.

## *Stirring*

Pfeiffer, (1948, 1956) mentions a 75% increase of oxygen in the water after 1 hour of manually stirring the biodynamic preparations into the water. Schwenk, (1962, 1989) and Filler, (1994) supported the hypothesis that water transfers information. Schiff, (1998) described the scientific relevance of the theory that water keeps the memory of dissolved substances. In New Zealand, flowforms are used for stirring (Trousdell, 1990). Schikkor, (1994) suggested that flowforms were better than machine stirring but that hand-stirring gave the best results.

## *Compost preparations*

A number of scientists have looked at the effects of the biodynamic compost preparations on the decomposition of manure and compost in comparative trials. From visual observation, the preparations appear to increase decomposition of manure (Abele, 1987). Wistinghausen,

(1986) found an increase in the cation exchange capacity of manure piles and differences in their ammonium and nitrate content, indicating that the biodynamically treated manure was further decomposed. Ahrens, (1984) saw greater decomposition in biodynamically treated straw, shown by a higher ash and lower carbon content and a higher carbon/nitrogen ratio. Abele, (1987) found significantly higher organic matter, higher nitrogen dehydrogenase and cellulolytic activity, more humic acid, greater humification of organic matter and higher levels of Azotobacter and nitrogen fixation by free-living nitrogen fixers. In a long-term trial (1980–1984) with mineralised, organic and biodynamically fertilized vegetables, Abele, (1984) found the lowest nitrate content in biodynamically treated samples. Under optimal storage conditions the durability of products shows only small differences. However, under stress conditions (temperature, humidity, chopping up), clear differences occurred in terms of microbial attack and degradation, in favour of biodynamically treated samples.

More recently Bachinger *et al.,* (1996) found the highest organic carbon content in topsoil following the application of composted manure and biodynamically treated manure. It took several years for the new organic carbon levels to be established, depending on the type of fertilization applied. Greater enzyme activity and larger microbial biomass with dehydrogenase activity was found in manure fertilizers, especially with biodynamic preparations. Positive effects of applying organic fertilization treated with biodynamic preparations had also been observed in the subsoil at a depth of 25–55 cm.

In a study on the metabolic activity of the soil micro-organism population in a clover/grass sown pasture, Hoffman *et al.,* (1997) observed that biodynamically treated grassland showed similar microbiological characteristics to soil under permanent pasture. Scheller and Raupp, (1997) observed that regular application of farmyard manure led to increases of both amino acid and humus contents of the soil, these could be increased further by the use of the biodynamic preparations.

The comparative trials of Reganold *et al.,* in New Zealand are discussed in other sections of this report.

## Recommendations for Further Research and Training

Whole farm biodynamic research is required in the context of the unique agro-ecosystems of the various regions in New Zealand. A cornerstone for such research is the application of participatory research approaches that draw together the knowledge of existing biodynamic farmers with complementary and conventional research methods.

Further research needs to focus on the following areas:

- the use and value of the biodynamic preparations, in particular the hornsilica preparation, for crop development and farm ecosystems in New Zealand;
- active perception and evaluation of the biodynamic preparations by New Zealand farmers and investigation of the outcome in cooperation with scientists;

- optimum processes for production of the preparations, including materials used and storage;
- the connection between the effect of the preparations on the plants and nutrition.

For biodynamic research to be made relevant to a wider community in New Zealand there is also a need to bridge gaps in knowledge and understanding through training in the research methods and approaches outlined in this report.

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# 6 RESEARCH REVIEW: SOCIAL AND ECONOMIC DYNAMICS OF ORGANIC AGRICULTURE

## Overview of Material Covered

This chapter presents the findings of a review of English-language literature on three aspects of the economic and social dynamics of organic agriculture. The research reported here is not research conducted by members of the organic industry themselves, or by research scientists with an interest in organics, rather, it is a collection of work by sociologists, economists and geographers who have observed the development of the organic sector and its social and economic dynamics. This section does not review the most voluminous economic work – analyses of organic market trends.

The three areas in which useful bodies of research have been conducted are:

- Evaluations and analyses of the socio-economic aspects of the development of the entire organic sector. This usually takes the form of regional, industry-level, country-specific or global reports on the development of organic agriculture.
- Economic analyses of the economic performance of organic production units. The English-language literature can provide a moderate body of data. It is clear, however, that a large number of European studies exist, but are as yet untranslated.
- Grower decision-making and conversion. One area of significant sociological analyses is the process by which growers convert to organic production.

## Recommendations

These three areas – with the exception of market data and analyses – provide the only English-language material that approaches adequacy in providing broad and repeatable analyses of organic farming. Other areas, including labour-use, community outcomes, and public health, have only been the subject of a limited number of studies.

A review of the current state of English-language studies into the social and economic dynamics of organic agriculture would suggest the following:

- New Zealand is well served with socio-economic evaluations compared to all other countries excepting mainland Europe. These still provide only patchy material, and needs better integration.
- While some areas – markets, sectoral development, economic performance, conversion/ attitudes – have an adequate body of research, other areas are extremely poorly served.

- Most of this work is episodic, isolated and idiosyncratic. Different social and economic facets of organic farming are rarely investigated in tandem, and little good research has taken place over time. Integrated whole-farm analyses, of multiple dimensions, over a lengthy time span, is urgently needed to create coherence in the evaluation of organic agriculture. New Zealand has the necessary body of preliminary work to support such an undertaking.

## Industry Development/Sociology

*General:* Literature that evaluates the global-level development of an organic agriculture sector is not common. The most prevalent global-level analyses involve marketing surveys. Most literature tends towards regional or country-specific development. Ritchie *et al.,* (2000) provide one overview of the global organic industry. They conclude that in 2000, organic production involved between 1–5% of the agricultural sectors of Western countries. The sector was growing at an average of between 25–35%pa, and average organic price premiums were around 25%.

*Country Specific:* There are now many country-specific studies of the emergence and development of organic agriculture:

- **Japan:** Amano & Ichiraku (1998)
- **USA**: Buck *et al.,* (1997); Goodman (2000); Groh and McFadden (1997); Guthman (1998, 2000); OFRF (1997); Nelson and Coyle (2001)
- **UK**: Clunies Ross (1990); Clunies Ross and Cox (1994); Reed (2001)
- **Europe**: Foster and Lampkin (2000); Kaltoft (1999); Kristensen (1999); Laajimi (1997); Lampkin *et al.*, (1999); Lohr and Salomonsson (1998); Lynggaard (2001); Michelsen (2001, 2001); Mononen (1999); Offerman and Nieberg (2000, 2000); Padel (2001); Pugliese (2001); Tovey (1997); Zanoli and Gambelli (1999); Zanoli *et al.*, (ND)
- **Canada**: Henning *et al.,* (1990); Hill and McRae (1999)
- **Australia**: Lawrence and Lyons (1999); Lyons *et al.*, (2000)
- **Mexico:** Nigh (1997)
- **Cuba:** Rosset (1998).

These regional or country-specific studies heavily favour the EU. As the list below suggests, New Zealand has actually been as intensively studied as almost any other part of the world. The low volume of literature on organic agriculture in the US is surprising. The almost total absence of English-language work on Japan is also surprising. This review, however, clearly emphasises the disparity between First World and Third World literatures. Organic agriculture is a First World phenomenon. While much of the Third World is already engaged in sustainable and organic systems, research has tended to evaluate the direct conflict between organic and intensive agriculture in the First World.

## New Zealand Studies

- *NewZealand-General:* Campbell (1996, 1997); Campbell and Coombes (1999a. 1999b); Campbell and Fairweather (1998); Campbell and Liepins (2001); Campbell and Fitzgerald (2000); Coombes and Campbell (1998); Liepins et al. (1997); Saunders *et al.,* (1997)
- *Honey Industry*: Bourn *et al.,* (1999)
- Canterbury Region: Campbell (1996)
- *Kiwifruit Industry:* Campbell *et al.*, (1997)
- *Nelson Region*: Coombes and Campbell (1998)
- *Gisborne Region:* Coombes *et al.,* (1998)
- *Wine Industry:* Fairweather *et al.,* (1999)
- *Livestock Industry*: Richardson (1999)

*Analysis of Industry Development*: Much of the industry development literature is descriptive. However, there is a significant debate running through some industry development literature that concerns the impact of commercialisation on the organic sector. There are questions raised about whether organic agriculture can occur in capitalist contexts:

- USA
  - Guthman (1998, 2000), Buck et al. (1997); Goodman (2000)
- Europe
  - Kristensen (1999) and Kaltoft (1999)
- Australia
  - Lyons et al (2000)
- New Zealand
  - Campbell (1996, 1997); Coombes and Campbell (1998); Campbell and Liepins (2001).

All these regions are examined and evaluated to determine the consequences of commercialisation. In all these literatures, commercialisation is seen as providing a major impetus to the rate of growth of the organic sector. However, the cost of commercialisation is usually seen as being a downgrading of some of the original priorities of the sustainable agriculture social movement, pressuring standards in some countries, and increasing concerns about food miles and simple substitution of organic inputs into conventional farming systems.

## Economic Performance

*On-farm Performance:* There is a growing body of work that makes financial performance evaluations; comparing organic and conventional production. The most important are:

- Offerman and Neiberg (2000a, 2000b); Zanoli and Gambelli (1999) ; Zanoli *et al*., (N/D); Mononen (1999) ; EAP staff (1997); Fowler *et al*., 2001a, 2001b); Foster and Lampkin (2000); Reganold *et al.,* (2001).

For New Zealand there have been few performance evaluation undertaken, with Saunders *et al*., (1997) reviewing the work done to that date. No subsequent work has been undertaken.

*Financial Impact in Wider Economies:* The greatest amount of work is done in the form of policy studies which seek to evaluate the potential financial impact of organic farming in Europe. This includes wide ranging studies by:

- Fowler *et al*., (2001b); Lampkin, (1999); Offermann and Neiberg, (2000a, 2000b)

Thus there is a significant gap in the literature of economic analysis of organic farming. This relates to studies of on-farm economic performance - especially for countries other than Europe. Little data is comparable, and there is little time-series data. Likewise, on-farm data has not touched on the effects of on-farm processing and marketing.

## Grower Conversion

The records fall into two groups: those that debate the process of deciding to convert from conventional growing, practices, to organic, and those that concentrate on the financial advantages or otherwise of the conversion.

There are two different analytical approaches to the process of organic conversion.

*Goal Analysis*: Zanoli, *et al.*, (ND) look at it in terms of goals and influences on their achievement. They see the decision-making process as moving from a perception of the goal through an analysis followed by a decision. They describe a number of factors that impact during this progression.

*Decision Tree Analysis*: Fairweather, (1999) and Fairweather and Campbell, (1996) use a decision tree analysis to follow the progression from a conventional farming mind set to that of an organic grower. They group factors as, eliminating, constraining or motivating. The factors and groups are reviewed again in Cook et al. (2000).

An amalgamation of the decision-making factors that are discussed by authors in the database follows.

## Factors Involved in the Decision to Become an Organic Grower

- Grower eliminating factors
  - Unaware of the organic system
  - Satisfied with their current intensive, high input system
  - Satisfied with their current low input system
  - Individual is convinced that organic growing is not technically or financially viable
- Grower Motivating Factors

  *Personal, background factors*
  - Philosophical inclination/concerned about the environment
  - Having a higher level of education
  - Pro-organic parents/other role models
  - Being younger
  - Being female
  - Being a parent
  - Ethnicity

  *Working experience factors*
  - Health; worried about danger of sprays to applicator and/or consumer
  - Cost of inputs in conventional growing
  - Problems with conventional systems
  - Anxiety over soil fertility and organic matter levels
  - Need for, or reward of, price premiums
  - Need for, or reward of, subsidies
- Constraining factors

- Unaware of the organic industry
- Lack of information about organic methods
- Lower average production
- Increased exposure to risk (disease, weeds, climatic)
- No organic way of growing their speciality crop
- Lack of suitable organic techniques x crops to suit their climate/soil resources
- High debt level, lack of capital to survive conversion years +/risk
- Unconvinced peer group (cultural norm)

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# List of Useful Sites

### ORGANIC FARMING IN EUROPE: ECONOMICS AND POLICY

**www.uni-hohenheim.de/~i410a/ofeurope/**

Date accessed: 13 August 2004. Last site update: Not specified. Supported by the University of Hohenheim; this site aims to be an independent forum; offering a series of publications containing in-depth and up to date papers on organic farming in Europe to an international audience. The site also aims to be a forum for scientific debate on the subject.

### WELSH INSTITUTE OF RURAL STUDIES. UNIVERSITY OF WALES, ABERYSTWYTH, UK

Includes: Organic Centre Wales.

**www.irs.aber.ac.uk/research/agroecology.shtml**

Date accessed: 13 August 2004. Last site update: Not specified. The group is established as a leading centre in Europe for organic farming research. Much of its published work has been carried out in collaboration with researchers in rural economics and development, social scientists, soil and animal scientists, and ecologists.

### ECOLOGICAL ECONOMICS

**http://www.elsevier.com/wps/find/journaldescription.cws_home/503305/description#description**

Date accessed: 13 August 2004. Last site update: 11 August 2004. This journal, published by Elsevier Science, is concerned with extending and integrating the study and management of ecology and economics. It aims to be methodologically open as well as transdisciplinary: "This integration is necessary because conceptual and professional isolation have led to economic and environmental policies which are mutually destructive rather than reinforcing in the long term."

### EUROPEAN COMMISSION – ORGANIC FARMING

**europa.eu.int/comm/agriculture/qual/organic/index_en.htm**

Date accessed: 13 August 2004. Last site update: 10 August 2004. This is the address for the European Commission's policy on organic agriculture. It links to a guide to the European Community rules for organic farming.

### OFRE: ORGANIC FARMING RESEARCH FOUNDATION

**www.ofrf.org/index.html**

Date accessed: 13 August 2004. Last site update: Early 2004. "The Organic Farming Research Foundation is a non-profit foundation founded to sponsor research related to organic farming practices, to disseminate research results to organic farmers and to growers interested in adopting organic production systems, to educate the public and decision-makers about organic farming issues." Its objective is "to foster the improvement and widespread adoption of organic farming practices". It has links to many related sites, which are organized into themes including research and education, policy and government, organic and sustainable agriculture organizations, international organic sites, and farming in general.

### NATIONAL ORGANIC FARMERS SURVEY

**www.ofrf.org/publications/survey/index.html**

Date accessed: 13 August 2004. Last site update: Not specified. In spring 2002, OFRF mailed a 22-page survey to certified organic farmers throughout the U.S, with 1,034 farmers responding, an 18% response rate. OFRF's latest survey results were published in July 2004. **The Fourth National Organic Farmers' Survey: *Sustaining Organic Farms in a Changing Organic Marketplace***, gathered information on a wide variety of topics related to organic markets and marketing

### ATTRA: APPROPRIATE TECHNOLOGY TRANSFER FOR RURAL AREAS

**http://www.attra.org/**

Date accessed: 13 August 2004. Last site updateNot specified. ATTRA — Appropriate Technology Transfer for Rural Areas — is a leading information source for farmers and Extension agents thinking about sustainable farming practices.

### CENTER FOR INTEGRATED AGRICULTURAL SYSTEMS

**http://www.cias.wisc.edu/**

Date accessed: 13 August 2004. Last site update: Not specified. The Center for Integrated Agricultural Systems (CIAS) was created in 1989 to build UW sustainable agriculture research programs that respond to the needs of both farmers and citizens. It is a small sustainable agriculture research center at the University of Wisconsin's College of Agricultural and Life Sciences, and aims for multidisciplinary research into various aspects of food and agriculture issues.

### CAFRE: THE CENTRE FOR AGRICULTURE FOOD AND RESOURCE ECONOMICS

**les.man.ac.uk/ses/research/cafre/Default.htm**

Date accessed: 13 August 2004. Last site update: June 2004. This is a centre for research in the areas of agricultural, natural resource and environmental economics that operates from the School of Economic Studies, Manchester University, UK.

### OPENZ: ORGANIC PRODUCTS EXPORTERS OF NEW ZEALAND INC

**http://www.organicsnewzealand.org.nz/**

Date accessed: 13 August 2004. Last site update: 11 August, 2004. OPENZ is a network of businesses, research institutions, consultancies and certifying agencies formed in 1995 with support from the New Zealand Trade Development Board, (Now NZ Trade & Enterprise). OPENZ has been a powerful instrument in the spectacular rise in organic production and exporting from New Zealand. It continues working to sustain the momentum through supporting: growing, processing and marketing; and by lobbying and working with government departments on behalf of the industry. The OPENZ site offers: information, and marketing support sevices.

## EAP: ECOLOGICAL AGRICULTURAL PROJECTS

**www.eap.mcgill.ca/general/home_frames.htm**

Date accessed: 13 August 2004. Last site update: Not specified. This is a resource centre for sustainable agriculture, that contains magazine type articles and interesting technical advice. Membership and contact details are provided.

## CANBERRA ORGANIC GROWERS SOCIETY INC.

**http://www.cogs.asn.au/**

Date accessed: 13 August 2004. Last site update: Not specified. The *Canberra Organic Growers Society Inc*. is a non-profit organisation started in 1977 with the aim of providing a forum for organic growers to exchange information, and encourage the general public to adopt organic growing methods. Currently has about 230 members. COGS is run by volunteers. This web site has been provided as a public service.

## QUEENSLAND GOVERNMENT DEPARTMENT OF PRIMARY INDUSTRIES

### Trade Opportunities for Organic Food

**www.dpi.qld.gov.au/business/1538.html**

Date accessed: 13 August 2004. Last site update: 11 May 2004. This government department site provides information on business, markets and trade in primary industries, and includes documents on organic production, processing and certification. It also provides analyses of markets, demands and opportunities for organic food, including the export markets in Japan, Hong Kong, Taiwan, United Kingdom, France and Germany.

## USDA UNITED STATES DEPARTMENT OF AGRICULTURE

**http://www.usda.gov/**

Date accessed: 13 August 2004. Last site update: Not specified. This is the search page for the United States Department of Agriculture, which allows access to USDA information on organic agriculture largely drawn from their Economic Research Service.

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*His primary lecturing and research activities are in cell biology, soil biology and biochemistry (e.g. biological nitrogen fixation), and microbial ecology; and in coordination of the course, Organic Farming Systems. Research activities and interests have centred on the use and stability of microbial inoculants, and the biology and ecology of land-use systems (waste disposal systems and composting, nutrient cycling, biology of organic farming systems, soil quality). He is author/co-author of over 80 publications and presentations.*

# 7 CASE-STUDY OF NEW ZEALAND DAIRY FARMS IN TRANSITION

## Introduction

In the early 1990s a field research-project established by staff of the former Department of Soil Science at Massey University was amongst the first in New Zealand to gain first hand comparative information about the field performance between long established organic farms and their equally long established conventionally farmed counter parts. "Organic", here, refers to farms that were already certified according to internationally accepted organic standards of the day (i.e., BioGro or Demeter).

The results of the early 1990's project, led by visiting academic researcher Dr John Reganold of Washington State University, USA, became the subject of a 1993 scientific report published in *Science (Soil Quality and Financial Performance of Biodynamic and Conventional Farms in New Zealand).* In New Zealand organic circles this publication is still popularly referred to as the Reganold report, as it presented data on measured differences in both soil quality and financial performance of seven matched pairs of farming activities in New Zealand, each matched farm-pair comprising a Demeter certified farm and its adjacent but conventional counterpart. The only significant difference between members of each matched farm-pair was their management and farming methodologies. Each Demeter farm involved in the study had been under organic management for a period of at least 10 years.

The abstract of the Reganold report, as published in *Science,* reads as follows:

> Biodynamic farming practices and systems show promise in mitigating some of the detrimental effects of chemical-dependent, conventional agriculture on the environment. The physical, biological, and chemical soil properties and economic profitability of adjacent commercial biodynamic and conventional farms (16 total) in New Zealand were compared. The biodynamic farms in the study had better soil quality than the neighbouring conventional farms and were just as financially viable on a per hectare basis.

For a new case study, the approach was to establish and compare important farming parameters of closely paired farms in which the organic farm of each pair, in contrast with the earlier 1993 study, was starting the transition stages of conversion from conventional to organic status, and was thus committed to organic management methodologies that could lead to full organic status and certification (Demeter, in this case). A compelling and practical reason for initiating a new study was to determine the sort of changes in farm performance (in the widest sense) a grower could reasonably expect to encounter that might likely influence on-going farming decisions during transition from an existing conventional state to organic status. Most farm organic conversions are believed to begin in this or a similar way

## Present Case-Study

### *Background and funding*

For this case study we chose to focus on commercial dairy-farm units as such farm-systems include not only soil, pasture, and milk production, but also animal-health and reproduction. Initially, farm-pairs at five potential North Island sites were evaluated for suitability and comparability. These potential sites were situated at Te Aroha, Newstead (near Hamilton), Maungatawhiri (southern edge of the Bombay Hills), Matarau (near Whangarei), and Te Kopuru (near Dargaville). As in the 1993 research, the process of matching farm-pairs was an integral part of the study and was based on similarities of soil pedology, slope of land and topographical aspect, pasture history, livestock and dairy herd composition, and fertilizer history along with soil tests.

While there were quite distinctive differences between the five geographic sites, we judged that the farm-pairs at only two sites had sufficiently comparable features to be included in the new study. These were matching farm-pairs at Te Kopuru and at Te Aroha, and we designed a sampling programme based on the physical aspects and stocking history of each farm-pair. Chief among the farms' matching features were their pedological characteristics, as essential recognition that soil not only has potential for determining pasture growth but can also have a primary influence on livestock performance and therefore milk production. While conventionally managed farms would continue to use soluble fertilizers like urea and superphosphate, proprietary animal drenches and ectoparasite insecticides, and herbicides for weed control, transition farms would cease using such methods and adopt the organic methodology as proposed (in this case) by the Biodynamic Association.

The Pacific Development and Conservation Trust agreed to fund the project on a year-to-year basis over a rolling 3-year period. However, due to an exceptional call on Trust funds during the first year of the project, funding for years 2 and 3 was cancelled. This project, therefore, ultimately had funding to collect samples and obtain data for only the initial period of about a year.

## What was Measured?

Five measurement categories involving the two paired dairy-farm sites selected for this study were chosen to achieve the project objectives:

- Milk production (based on monthly receipts from the respective dairy cooperatives)
    - milk volume in litres; protein to milk fat ratio; milk-solids in kilograms; somatic cell counts.

These values were extracted from monthly farm dairy-receipts issued by the dairy factory processing the milk. In order to have more inclusive values for each farm, it was also necessary to add the volume of milk used in calf rearing over the 8-week period this feeding was done.

- Animal Health Data (as available)
  - faecal-egg counts on calves; liver biopsy values for selenium, copper, and cobalt;
  - live-weight data.

The veterinary parasitology laboratory at Massey University determined faecal-egg counts. Early and high egg-counts are often diagnostic of young dairy animals under stress. With calving almost a year-round activity on many organic dairy farms, sampling was more frequent (several times per year) than for conventional herds.

Adequate levels of selenium, copper and cobalt in dairy herds are considered to be a prerequisite for successful reproductive performance. Analyses were conducted on animals from the main dairy herd, and at irregular intervals of time. Samples of liver tissue were submitted to New Zealand accredited analytical laboratories for analysis.

- Pasture Production (monthly, depending on season).
  - herbage dry-matter yields; major herbage components.

Pasture-cages were placed on pasture sites of each farm and herbage growth was trimmed to constant height, weighed fresh in the field (non-rainy days) and a grab-sample of the mixed herbage sent immediately by courier to Massey University for dry matter content and determination of the herbage-split (i.e. composition ) of the total herbage sample. Following grazing of each pasture site, the pasture-cages were re-sited to protect the development of new pasture growth.

Pasture herbage composition was conducted on each field sample in the laboratory, and for the Te Aroha site was expressed as percentage of rye grass, clovers (red and white), and other herbage (rather than weeds). At the Te Kopuru site, a fourth category , kikuyu grass, was required as this was a significant pasture herbage component in Northland pastures

- Soil Analyses ( initially and annually)
  - total organic carbon, total soil nitrogen, total soil phosphorus, cation exchange capacity (CEC), exchangeable levels of potassium, calcium, magnesium, sodium, pH;
  - biologically mineralisable nitrogen, soil respiration, and pasture earthworm count.

All these soil tests were made using well-established analytical methodologies of soil analysis by the Fertiliser and Lime Research laboratory at Massey University. At each farm-site a collection of 10 x 15 cm-soil cores was pooled from each of 5 field sampling sites under pasture. Soil sampling took place during late winter (August) of each year when it was believed analytical results would be at their most reproducible, particularly counts of pasture earthworms. The soil sampling protocol was similar to that used in the earlier Reganold report.

- Climate data.

We ensured that daily rainfall data and soil temperature data could be manually collected on one farm of each pair (normally the farm in organic transition) on a daily basis throughout the project. Rain gauges were provided and soil temperature was measured at a depth of 5 cm using thermocouple thermometers. Due to the close proximity of matching-farms to each other, rainfall and soil temperature data values were assumed to be identical at each of the two geographic sites.

## Project Participants

It was originally planned that the research project would involve not only soil scientists and a veterinarian from Massey University, but also farming staff and managers as active collectors of field-data at both Te Aroha and Te Kopuru study farms. As both field-sites in the project were several hours driving-time away from Massey University, farm owners agreed to undertake regular monitoring of rainfall and soil temperature as well as pasture herbage sampling.

The farming staff on each organic unit undertook these regular tasks on their farm as well as on the matching conventional farm in addition to their regular chores. Before pasture-collection activities began, there was an orientation session to go over the purpose and details of sampling, and to seek and obtain agreement that farming staff would undertake to record all relevant observations and dates in a farm-diary kept on-farm so that apparently small and apparently trivial farm events could be reviewed as necessary at a later date. We considered this aspect of the field project to be of particular significance as it not only enabled the regular collection of on-farm data of considerable value to the project, but extended the responsibility and ownership of this data to the farm owners themselves and so promote understanding.

The Massey academic staff-members involved were established researchers with international reputations and were involved in organic programmes and workshops. The project emphasised and required expertise in soil genesis, soil-plant-animal relationships, experience in monitoring organic farming systems, and a successful rapport with farmers of organic livestock. Animal health issues related to animal parasite burdens, mastitis, and reproductive disorders linked to micronutrient deficiencies in animal diet were an important dimension of the project.

## Collection of Data

As reported to the owner of each farm by the respective dairy company, the volume of milk actually collected by tanker was a primary measure of milk production from each herd over the month being reported. The volume of milk used for on-farm activities, such as calf feeding, was estimated from feeding procedures and added to tanker-collection volumes. On conventional farms, calves received 4 litres per day, while calves on biodynamic farms were fed at 6 litres per day and for a longer period.

Somatic cell counts were normally reported along with each month's milk-production data from the respective dairy company for each farm.

Soil collection protocols and analytical services were similar to those used in the earlier Reganold project and results were reproducible to $P < 0.01$.

Pasture production data were more variable. At each field-sampling, pasture herbage was sampled on each farm from 6 small cages (each approximately 0.4 square metre), the cut-herbage pooled and weighed fresh. After determining moisture content in the laboratory, the percentage dry-matter was calculated and expressed as kilograms on a per hectare basis per day over the specific growth period. Comparisons of monthly values were plotted to give visual comparison of pasture production within each farm pair.

## What did the Farm Measurements Tell Us?

To make an interpretation of any differences that might be detected between farm-pairs, there are several assumptions about each farm-pair that first need to be identified. For example, at the outset, it had to be assumed that the farms in each matched pair were at almost identical stages of development, pasture composition and age, and stocking rates, and that the dairy herds were of similar genetic potential and receiving equivalent treatment and care.

However, the dairy-farm sizes were not strictly identical, and it was further assumed that this would not have a significant effect on the measurements about to be made. For reasons of both insufficient planning-time and inadequate funding, we were not able to confirm any of these assumptions with actual pre-project evaluations. Both conventional dairy farms in the study used "run-off" properties as an integral part of their livestock management programme.

Measurements and determinations were made when management methods intended to lead ultimately to full organic status were first implemented, and then at regular times, as specified, throughout the following 12 months. Time related trends (e.g. estimations of pasture growth) were plotted throughout this period. Soil analyses were conducted only at the outset, and then 12-months later.

## Size of Dairy Herds and Stocking Rates

Conventional dairy herds were numerically larger than those undergoing organic conversion, in one case only marginally (130 v 126), but significantly so in the other (220 v 150). Overall stocking rates were on average greater (2.2, 2.3 cows per hectare) on conventional farms, compared with 1.8, 1.5 cows per hectare on the transition farms.

## Milk (Based on Factory-collection Data)

In terms of milk-solids produced *per hectare*, the estimated average for conventional milkers was 400–420 kg compared with 340–360 kg for transition milkers. When expressed on a *per animal* basis, conventional milkers generated on average 300 kg compared with 230 kg for transition milkers.

On a volume basis, milk production (litres per cow per month) on the conventional farm was up to 1.5 times greater than that on the transition farm over the July–October spring period. By December, milk production on both farms was similar for the rest of the season.

## Pasture Herbage Production

From July to June of the project period, the estimated *annual* dry-matter production of herbage at the more northerly Te Kopuru sites were 21.5 tonnes per hectare on the conventional farm, compared with 16 tonnes per hectare for the transition farm. However, seasonal production (kg DM per ha per day) was not identical with a greatest daily production of 80 kg DM occurring during the September–October period on the transition farm pastures, compared with about half that daily rate on the conventional pasture. Pasture production on conventional pasture during the late-season April–May period gave a considerable boost to annual DM values.

There were no major surprises in the seasonal herbage composition of pasture. The percentage of clover herbage in pasture sampled during the February–May period tended to be greater on conventional pastures. Overall, both ryegrass and kikuyu components dominated pasture composition on both farms.

Pasture plants in the herbage identified as not being rye grass, kikuyu, or clover, were identified as “herbs”, and were a measurable DM component of transition pasture herbage yields. At the Te Kopuru site, the “herb” component accounted for 10–15% of the DM production during the Spring period (July–September), and at the Te Aroha site, the “herb” component accounted for over 20% of the DM produced during the January–March period. As such, the “herb” component of pasture herbage was believed to be a significant dietary input for those animals.

## Animal Health and Performance

An overview of the following are reported here: somatic cell count (SCC) in milk, faecal egg counts (FECs) for yearling heifers, levels of copper, selenium, cobalt (vit B12), and liveweight values of rising two-year-olds.

The Te Kopuru site milk-analyses gave a better data set for comparing SSCs throughout the season. Milk from the conventional herd starting in August had SCC-counts of 160–200 thousand and rose to 180–250 thousand by December, and later to 260–570 thousand in April. In contrast, milk from the dairyherd in organic transition started off at 140–200 thousand in

August, rising to 250–290 thousand in December, and to 290–490 thousand by the last milking in April. There appeared to be no significant differences between the herds under the two different field managements.

Similarly there appeared to be no dietary deficiencies of selenium, cobalt, or copper that would have significance in reproductive performance of the cows in the organic transition herds, at least as based on liver biopsy analyses. Similar analyses on animals from the conventionally managed herd indicated a need for remedial action to counter lower than desirable levels of copper. Analyses were carried out at the Auckland Animal Health Laboratory of MAF.

With only one exception, there was no significant numerical difference in FECs between yearling stock under either management. Analyses were carried out by the Parasitology Laboratory at Massey University.

Only one animal liveweight measurement was made of one year-old (12–14 months) Friesian calves for one matched farm-pair (Te Kopuru site). In September, 63 conventionally managed animals averaged 269 kilograms, while 30 organic-transition animals averaged 249 kilograms (CV~10%).

## Soil Analyses

Based on comparisons of eight different analyses carried out initially and 12-months later on soil sampled from both farm-sites, there would appear to be no statistically significant changes in the levels of most plant-available soil nutrients and certain biological activities after one year of transition organic management.

There were two exceptions. Levels of soil sulphate and Olsen-P for conventionally managed farms remained between two to three-times greater than for transition organic farms. A simple explanation to account for this is that pasture applications of superphosphate continued as part of regular conventional farm management, while it had ceased for organic farm management.

There was some evidence, based on laboratory respiration studies, that soil from the transition farms had marginally increased its level of soil microbial activity over that of soil from conventional farm sites. This is entirely consistent with the findings of the earlier Reganold Report.

## Climate Data

As the overall enterprise of each closely matched farm-pair was almost identical in operation as well as geographic site, temperature and rainfall data collected at only one farm of each pair was considered to be necessary. It had originally been anticipated that the field project would run over 3 years, so in order to help interpret likely seasonal differences over the 3-year period, a regular log of both daily soil temperature at 5 cm and rainfall was recorded by the farm managers. In this way it would be possible to see both the intensity and duration of rainy periods in any month of dairy production. As already pointed out, the project was reduced to a single year study due to funding restrictions and seasonal comparisons could therefore not be made.

At the more northerly site at Te Kopuru, just inland from the western coastline, soil temperatures at 5 cm remained above 10C throughout the year. They exceeded 20C during January and February. While monthly rainfall was fairly evenly distributed throughout the year (1300 mm), daily rainfall was restricted to just a few days in the months of February to May.

At the Te Aroha site, on the western flanks of the Kaimai Range, monthly soil temperatures dropped below 10C in July and August, but also exceeded 20C in January and February. Monthly and daily rainfall values were more evenly spread throughout the year (1400 mm).

## Discussion and Conclusions

The project restricted to a one-year study fell far short of providing adequate information that would have been useful in constructing a more useful picture of the nature of the differences in those parameters chosen for measurement between dairy farms remaining under conventional management and those being deliberately managed towards achieving organic certification. There remains to the present day a scarcity of comprehensive information about the effects of the process of organic conversion on dairy farms, the transition effects on livestock production and dairy performance, and soil-plant interrelationships in grazed pastures in New Zealand.

In this preliminary case-study some interesting differences came to light, some of which were actually observed in pasture growth, for example, the proportion of "herbs" to normal pasture species and the implications this could have for ruminant animal nutrition. Some were not recorded as a part of regular data collection, but became a part of the growing flow of anecdotal information provided by the farm managers themselves. For instance, veterinary costs on transition farms were said to be reduced even, in the first year of operation, up to 90% as claimed by one farmer. However this was offset by the time required to learn about herbal and other remedies used in organic livestock management.

There was no convincing evidence that taking a conventional dairy farm and placing it under organic management methodologies would inevitably result in a dramatic decline in the farmability of land so often prophesised in the past. On the contrary, even in the first year of conversion, there were signs of physical and biological improvements to farmland under conversion, as well as repeated farmer observations that cases of bloat were being halved, even though the farms now in transition had a prior history of significant cases of bloat under conventional management.

It is strongly suggested that for future case studies, consideration be given to using established methodologies that enable evaluation to be made of the dietary and health effects of organic management on livestock performance. It is further recommended that the externalities of the environmental and sociological consequences of such comparisons be integral features of such research.

All farms in the study were commercial units and have remained so.

## Acknowledgements

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The Pacific Development and Conservation Trust.

*Gary Blake completed an M.Sc, Physical Geography, at the "University of Canterbury, post graduate Hydrological Studies at the Technical University, Budapest and a Teaching Diploma, Auckland College of Education. He has extensive practical and theoretical experience in many aspects of resource management and environmental impact. The Ministry of Works and Development provided many experiences including the opportunity to learn Hydrology, the value of the river catchment as a planning unit and research into soil/water/plant relationships. With Tonkin and Taylor, Consulting Engineers, river basin and water resource studies were completed in Malaysia and Indonesia, together with a period at FRI, Malaysia, to study the impact of logging on tropical rainforest. An extensive period of secondary science teaching has enabled experience to be passed on to students in the laboratory. Today he and wife Jan are developing their Thames Coast farm for education and tourism activities.*

# 8 WATER

The organic alternative is a broad and very holistic procedure for restoring our overworked environment. When hydrologist Viktor Schauberger told us to observe Nature and then copy he defined the organic method (Alexandersson 1976). Nature provides the only yardstick whereby we can measure the success or failure of our actions. Since the Industrial Revolution we have constantly gone against the mechanisms of nature, and our environment is paying the price.

Organic land use traditionally refers mostly to pasture, crop and orchard uses. Ostergaard, (1996) and IFOAM broke new ground with the inclusion of agroforestry. Forestry has not normally been seen as organic although permaculture has done much to change this (Mollison, 1987).

The diverse, highly structured, mature forest produces the best supply and quality of water.

> Let us begin by recalling some unspoiled brook that we may have seen making its way through dark forest depths, now burbling over pebbly stretches, now pent up in quiet pools. It sparkles in the changing play of light that breaks through the screen of foliage above; it leaps in rippling wavelets, alternating between soft murmuring and silvery tinkling. It takes a meandering course among the trees, twisting this way and that as though to make its lively game last longer. Surely this water cannot be called anything but living. (Schwenk and Schwenk 1989). The natural habitat of water is the forest.

Energy is "organic" if it does not impose adversely on Nature. Energy constantly moves between potential and kinetic levels and is part of the Universal system that exists in myriad of forms, most of which are not understood (Atkinson, 1989; Blake & Bacchus, 2000). School children have demonstrated that radishes will grow well if they are planted in phase with the Moon (Kerr & Marshall, 1997) and Rudolf Steiner's agriculture lectures indicate the importance of astrological energy in explaining soil health, plant growth, animal well being and pest management (Steiner, 1993).

## Water is What?

Water is life but is it living? The nemonic MRS GREN reminds us that to be alive we must be mobile, respire, sensitive, grow, reproduce, excrete and eat (nutrition). Water does not meet all these requirements, but without it we die.

Water is living by virtue of its role as the basis for life. By renouncing any form of its own it creates the matrix for form in everything else. By not meeting the requirements of MRS GREN it becomes the primal substance of all life. By not being materially fixed it implements material change, and by lacking rhythm of its own it creates rhythm elsewhere.

In all cultures water has been held sacred as a magical transforming substance "water of life" (Schwenk & Schwenk, 1989).

By virtue of its mobile, neutral and solvent properties, water almost always contains other substances. Should the human body drink only pure water (obtained by distillation), then the water will seek out body nutrients and deprive the body of essential resources.

> Water is as vital to the regulation of climatological and weather processes as oxygen is to the breathing processes of living creatures; without it, everything would become a desert. (Schwenk and Schwenk, 1989).

Schauberger said the serious degradation in spring water quality was due to the demagnetisation of the water and the effect is like water losing its soul. The causes are removal of forest, excessive sunlight and the consequent overwarming of the soil. The springs dry up, habitats disappear and land-management problems increase (Coats, 1996).

Essential natural cycles like water and photosynthesis are under threat. The water cycle processes 3% of available water to provide the global freshwater supply. Society has great difficulty in grasping the need for moderation of water use. Part of the problem, says Steiner, is the way we teach natural science in our schools which still has an anthropocentric bias.

## Water Cycle and Processes

The water cycle is contained in the atmosphere that forms the life-support envelope around the planet. Its outer limit occurs where the earth's gravitational pull approximates the centrifugal force caused by rotation 30000 km above the surface. The Troposphere is the lower 14 km or zone of clouds, storms and convection, and is home for the water cycle.

Critchfield, (1960) says the Earth's atmosphere is probably a secondary atmosphere evolving from volcanic eruptions, hot springs, chemical breakdown of solid matter and vegetation. "An interaction of energy, land, water, air and plant and animal life constantly uses and renews the atmosphere." Tomlinson, (1992) states there are 12 global weather systems and that New Zealand is located in the Southern Westerlies that are modified by the presence of ocean and mountains producing a diverse hydrology.

Precipitation occurs when moisture-laden air rises, driven by solar energy, expands, and cools sufficiently for the water vapour in the air to reach condensation point. Nuclei are needed to create droplets that must grow if the rain is to reach the ground. Where no nuclei exist, the air may become supersaturated with water vapour. Failure to ignore the workings of the sensitive atmosphere by altering the concentrations of gas emissions i.e., oxygen, carbon oxides, sulphur oxides, halogen gases, methane and particulate matter is inevitably creating changes in weather and climate.

Water reaches the land surface as snow, rain, hail and fog. Here it is either intercepted by vegetation and evaporated or throughfalls to the soil where it can surface runoff, evaporate, or infiltrate to recharge soil moisture and groundwater. Blake, (1975) studied ranges of vegetation for their ability to intercept rainfall from alpine herbfield/pasture, shrubs and large forest species. For shrubs and trees, the annual amount of rainfall intercepted varies between 15% and 40% of annual rainfall. Shrubs are usually about 20%, although dense stands of gorse will intercept 60%, pines about 25%, and indigenous species about 35%. A 40% figure for kauri compared favourably with a study done in Malaysian hill forest, which has a very similar form. The interception value is important when considering water yield, erosion prevention and shelter for stock. It also affects the growth of sub-canopy crops.

The presence of a wet canopy is also important in controlling the movement of water and minerals from the root zone throughout the plant. Water reaching the stomata in the leaves through the stem xylem is transpired to the atmosphere when intercepted water is absent. Otherwise the stomata are temporarily closed. The transpiration rate may be 50% of the annual rainfall, and represents a substantial proportion of the annual site water balance.

Soils are the product of biological and climate activity operating on geology. They are classified according to the size of their peds or particles ranging from the smallest clay, through silt to sand. The gaps inbetween are pores, and usually make up between 40–70% of the soil volume. The pores fill with nutrients, air and water. When filled with water pores will drain until a minimal amount of water remains attached to the soil particles. Water is freely available when the pores are full but as it drains a negative soil water pressure develops. The pressure holding the water is greater when the pore size is small. Gravity assists this process. Two characteristics define soil water movement: i.e., the hydraulic potential gradient or force, and the hydraulic conductivity that relates to pore-size distribution and water availability.

How these water characteristics vary can be shown by looking at three soil types — a sand, a silt and a loam. When the negative soil water pressure is high, plant roots cannot extract water. The sand contains little water, whereas the silt contains 30% water by volume unavailable to plants. The loam is inbetween. If 60 mm of steady rainfall occurs, it infiltrates into the loam and the sand. However, the silt is well compacted with many small pores, and 56 mm runs off while only 4 mm infiltrates.

After a storm, water moves down the soil profiles in response to gravity and capillarity. Most of the movement takes place in the first 2 days. In the loam, all the rainfall stays within the upper 0.5 m. In the sand, only 21 mm remain, and in the silt only 4 mm. This means that at an average daily evaporation rate of 4 mm, the loam has water for 15 days, the sand 5 days and the silt for 1 day. Water retentivity and conductivity by soils determines their ability to store water for plant use and allows soils to act as a buffer in catchment systems (Kelliher & Scotter, 1992)

Groundwater rises and falls, changing the dimensions of the unsaturated rootzone. Streamflow is sustained by groundwater discharge to the stream, and the flow rate responds to catchment geology. Duncan, (1987) summarises the hydrology of New Zealand catchments.

## Water Quantity

Land-use information is necessary for an understanding of New Zealand's water balance. The current state is:

| **New Zealand Land Use** | **Area (10–6ha)** | **Total Area %** |
|---|---|---|
| Indigenous forest/scrub | 6.2 | 23.0 |
| Pine forest | 1.0 | 3.7 |
| Urban | 0.4 | 1.5 |
| Lakes/rivers | 0.3 | 1.1 |
| Tussock/mountains | 4.5 | 16.7 |
| Improved pasture | 9.7 | 36.0 |
| Indigenous pasture | 4.4 | 16.4 |
| Fodder/cash crops | 0.4 | 1.5 |
| Horticulture | 0.04 | 0.1 |
| **Totals** | **26.94** | **100.0** |

(Rutherford *et al.,* 1987)

To assess the role of water and organics, we need to examine all land uses. In recent times some have become accustomed to heavy inputs from technology. To allow biological and environmental processes to prevail, the disruption to organics created by inappropriate technology must be removed (Niggli & Lockeretz, 1996)

Soil/water/plant processes are vital for a global tree planting and habitat restoration programme to boost water resources the photosynthetic process, and to reduce air temperature. However, hysteresis means restoration efforts will not produce an immediate response and will follow a clockwise loop before conditions improve (Gregory & Walling, 1973).

Permaculture offers a model on which to base a more balanced forested land use and improved water yield. Mollison, (1987) outlines the procedures and New Zealand farm forestry practice supports many of the concepts (Stockley, 1973). If 20% of a large property is planted in trees the crop yield will double on the remaining 80% of the farm. This was demonstrated on a Coromandel peninsula farm where 33% was planted in forest while sheep and cattle numbers remained the same.

## Land Use Effects

### *Forest*

Forests provide larger quantities of biomass than most other land uses but water relationships differ with forest types. Managed Pinus radiata forest and mature Kauri forest intercept 30–40% of rainfall, and transpire about 6 mm/day. The kauri forest is likely to be growing on volcanic clay soils with a substantial humus layer. Moderate infiltration and high water retention would ensure a good reliable supply of high quality water to the streams.

The pinus radiata sites are likely to have been more recently disturbed, and their soil profile will be less well developed. The humus layer will be less and, if the trees are growing on clay soils, the surface runoff will be considerable. However, if the site is on pumice soils, then surface runoff will be almost nil and infiltration almost infinite. While water flow in pumice may be far under ground, management of the forest may cause some changes to water movement. Top soil compaction increases surface runoff and reduces infiltration.

When the forest is clear felled, the intercepted water reverts to runoff and is discharged as quick runoff and the amount may be a 30% increase in the first year. The exact process will be unique to each catchment. After careful logging (skyline hauling) shrub vegetation reestablishes, and by 3–6 years stream flow is what it was before logging. Sediment yields also return to normal over the same period.

The water properties of forest species are an essential part of any sustainable land-use system, together with all the other forest attributes. Forest management must also protect the photosynthetic process on which all life depends. Long-term removal of forest will lower water tables and increase surface temperatures.

### *Shrub*

Because of variation in form, shrub types may intercept as little as 15% and as much as 60% of rainfall. Gorse may be very dense, holding large amounts of water amongst the densely packed spines. Broadleaf species, in contrast, intercept little. Their leaves are designed with drip tips to discharge rainfall.

Soils under shrubs are often quite shallow. Humus may be lacking but if it is present in abundance the water-holding properties of the soil will be enhanced and surface runoff will be reduced. Studies have shown that mature shrub stands (10–12 years) influence streamflow in a similar manner to mature forest given sympathetic soil characteristics, although the runoff increase as a percentage of annual rainfall can vary between 10% and 30%, depending on vegetation form.

### *Pasture*

Pasture species vary greatly in form, from tall tussocks and alpine herbs to introduced grassland species. The amount of precipitation intercepted can vary between 15% and 35% if plenty of biomass is present. However, where pasture is hard grazed interception is very low.

Peak runoff increases when the land use changes from trees to grass because the detention of rainfall is reduced. The planting of pastured catchments with pine species can reduce runoff by 27% at year 10. For tussock catchments this is about 20%. Pumice catchments have shown a 60% reduction although this reduces to 30% as the pines age year 22. Pines yield a little more runoff than indigenous forest species. New Zealand studies tend to support the findings of similar studies overseas. (Mosley & Pearson, 1997).

### *Pasture With Reference To Dairying*

Dairy farming usually takes place on lowland sites. Good quality water is required to water the dairy herd and in the milking shed, irrespective of the farming technique. The impact of dairy farming on water occurs in the paddock and the shed. Grazing and treading compact the site, allowing less water to enter the soil and more to runoff. They also alter soil physical and chemical processes, damage pasture, increase greenhouse gas emissions, and change soil fauna, according to Singleton *et al.,* (2000). The severity of the impact depends on the number of stock present, and shoud standoff pads be available during winter wet periods pasture and soil damage is reduced.

Surface runoff enriched by urine and faeces ends in depressions, drains and waterways. Stock in waterways add to the problem and increase turbidity. Infiltrating water enters the shallow groundwater that may be used for the farm water supply, and if it does not, it eventually flows into drains or streams.

Non-point discharges refer to water movement in the paddocks. Water associated with the milking shed is refered to as a point discharge. Twice a day for much of the year washing water enriched with excrement must be disposed of, and this has been done traditionally by feeding to a pond. Hickey and Quinn, (1992) found ponds to be highly variable performers with no relationship between effluent quality and pond size, and high concentrations of ammonia and faecal coliform bacteria. Barkle and Wang (2001) modelled nitrate seepage from ponds and found the concentration in groundwater to be 6 mg/litre@100 m distance, 2 mg/litre@500 m distance and 1 mg/litre @1000 m. Unfortunately, very few ponds are seepage proof, and before evaporation can take place the effluent enters the water table. The prefered method is now to spray this organic resource onto pasture (Environment Waikato, 1998).

The key water quality concern is the leaching of elements, particularly nitrogen, into the groundwater and waterways. Spraying of effluent onto pasture improves the pasture by providing water and organic fertiliser while an intact soil profile provides an efficient filter that strips nutrients from the infiltrating water. A Farm Design Model from Environment

Waikato, (2001) details a range of water-quality scenarios. Six different management systems are considered, and the amount of nitrogen reaching the stream is assessed. System 1 is a typical Waikato dairy farm producing 40 kg N/ha/yr to the nearby stream. The best of the alternatives reduced the dischrage to between 16–18 kg N/ha/yr.

Environment Waikato has a major interest in the quantity and quality of water discharging from dairy farms, advises farmers on a number of techniques to protect the water and users, including fencing waterways, which are of even more benefit to the farm if planted with trees. Trees are one of the many rhythms necessary to achieve sustainable farm management (Neugebauer *et al.,* 1996). The planting of species other than pasture can be a major method of stripping water of nutrients carried out for farms on a catchment basis. Other methods are standoff pads to rest pasture, management of stock numbers to avoid pugging, management of effluent from stock races, irrigation of shed effluent, and fertiliser control. Heatley, (1995, 1998) has compiled two comprehensive manuals on dairy farm and effluent management.

The Dairy Research Corporation has shown that farm effluent is capable of providing 150 kg N/ha/year. Applying more than 200 kg N/ha/year of effluent or urea will exceed the recommended limit for drinking water of 10 mg N/litre. Exceeding this fertiliser application increases environmental impact and costs the farmer (Environment Waikato, 1996). The effluent is a dynamic biological and chemical resource compared with the chemistry of urea. Nitrogen is a carrier of oxygen in the pasture, however, too much creates an oxygen deficit that affects pasture quality and dairy cows — their body temperatures are raised and calving is more difficult. Cameron and Trenouth, (1999) conducted/carried out a case study of farm dairy effluent management. The purpose was to assess whether desirable outcomes are being achieved at least cost.

## *Cropping With Reference To Orchards*

Orchards, whether citrus, nuts, avocados, kiwifruit, pip, berries, grapes, olives or flowers are usually located on flat or rolling sites with soils that benefit from irrigation. Ample supplies of clean water are needed to satisfy the many irrigation designs. The increasing demand on the water resource is a problem, for many orchardists water is a finite resource. At the start of this article, we concluded that water is organic because water is life. New Zealand research in horticulture is now showing that applying water to crops in sufficient quantity and quality allows the crops to grow without many historical props. Because of possible restrictions, orchards need to use water efficiently to achieve optimum results (Clothier *et al.,* 2001). If cultivation is involved on steeper sites, they should be contoured to minimise soil loss, conserve soil moisture, and reduce runoff.

Orchard crops are watered from precipitation, irrigation, and capillarity, should the water table be near the root zone. Water applied can either be intercepted by the canopy, runoff, infiltrate the soil profile and replenish soil moisture, evaporate or transpire, through the plant to the atmosphere. Most orchard irrigation systems apply water close to the soil to avoid runoff and evaporation losses. Overhead systems may also be used for frost protection.

In addition to lysimeter and energy balance methods it is now possible to measure water use by orchard crops using heat pulse techniques (Edwards & Warwick, 1984). For example in Marlborough on a hot sunny day with low humidity, small, medium and large olive trees used 3.5, 30 and 80 L/day of transpired water. On cool overcast days the rates are less (Green *et al.,* 2000), and when the canopy is wet-leaf stomata and rates are close to zero (Blake, 1975). This type of data allows irrigation needs to be refined.

Clothier and Green (1994) in their review of rootzone processes identified the importance of macropores in infiltrating water to depth under sprinkler and flood systems. Leaching of nutrients is less of a problem if "fertilisers" are first washed in, with a small amount of water, to allow capillarity to take the nutrients into the soil micropores. Work with kiwifruit has shown that plants rapidly change their spatial uptake of water in response to irrigation patterns. High frequency small applications of irrigation water are more efficient and kinder to the water resource.

Work with apple trees has shown that 70% of water uptake occurs in the top 0.4 m of the root zone, which contains 70% of the fine roots, as is the case for many plants. If the water supply to the root zone is uneven, those roots where water is plentiful will compensate for roots in the drier areas. When irrigation is applied, sapflow response is almost immediate (Green & Clothier, 1999).

Also of interest is the role of mulch, particularly for apples and grapes, although all crops would benefit. During the 1980s the use of mulch in Protea flower growing was rejected because it was considered to harbour undesirable organisms. Herbicides, pesticides and fungicides were considered inappropriate. HortResearch has now proposed contrary results as mulch increases soil moisture retention and adds to the development of the soil profile, soil temperature fluctuates less and the incidence of phytopthora fungi is reduced because of improved surface rooting. Calcium, potassium and magnesium are increased in the soil, and calcium and potassium in the leaves. Plant vigour and root density increases, while weeds become less.

Blake, (1999) has grown Protea flowers commercially without using irrigation and conventional sprays. Main aids have been to mix varieties, use companion planting, apply BD500 and a chilli spray for chewing insects. A neighbouring planting uses a conventional spray regime and it would seem easier to adopt the organic method as a first rather than second choice.

By observing Nature, scientists are finding that plants are more sophisticated than previously thought. They can protect themselves by physical means e.g., wax on leaf surfaces, leaf hairs, exudates, etc. However, when the first line of defence is challenged a surveillance system containing chemicals called "elicitors" responds the location of the invasion and sends warning message around the rest of the plant (Reglinski *et al.,* 2001). Not to observe Nature and to use pesticides and genetic modification is to not understand the plant. Research into water presence and movement in cells at the University of Auckland is advancing our knowledge on how plants operate (Wiggins, 1990, 1995, 1996).

The worldwide development of soil/water/plant restoration management systems is an urgent requirement and an important part of this is the relationship of precipitation to soil type (Bourguignon & Gabucci, 1996). The vitality of water to the concept of sustainable land use is well defined by Woodward *et al.,* (1996) who insist that, for organic systems to succeed, health must again become the main reason. Land users must have the information to make possible a more equitable, healthy and genuinely sustainable world. The increasing scarcity of freshwater is a critical problem.

## *Water Quality*

Water quality is difficult to define because it means different things to different people. Hoare and Rowe, (1992) make an interesting observation when they say that Maori are more concerned with the process water takes through the environment rather than what is in it, unlike the scientist. Maori developed the concept of Mauri by observing what happened in Nature. They lived by this, whereas most scientists analyse water by breaking it up to its physical, chemical and biological parts, which is contrary to the holistic processes of Nature and Maori.

From an organic perspective, the aim is to achieve water quality that generally coincides with that set by Nature for the particular catchment. Maoris' lack of understanding of water chemistry was not a problem. High nitrate levels, for example, did not exist and therefore did not concern them. If water supplies were drawn from fast flowing streams and springs, possible contamination would be minimal. Thermal springs would provide medicinal, bathing and cooking benefits and were not normally used for drinking.

Maori had to work with Nature and developed techniques that were sustainable. Many lakes for example were named after their water quality. At a Pa site, three water qualities were recognised: wainoa = excellent water quality; waimauri = common use quality; waitapu = sacred quality. Eels played an important part in maintaining water quality (T Winitana. *pers. com.*).

Close and Davis-Colley, (1990), studying the quality of 100 New Zealand rivers, found that while the range for each elemental ion varied greatly, the median concentration of the major elemental ions was lower than the world average, and very much lower than rivers in the USA.

However, the water quality of a particular farm or orchard is dependent on the condition of its catchment. A catchment in forest but recently treated with Talon and 1080 to control possums may have a lower water quality. The number of possums may also affect the water quality. Natural water quality can also be toxic, though not frequently. Some years ago mercury was found in fish from the Waikato river and investigations showed it was a natural cinnibar deposit and not the Kinleith pulp mill supplying the pollution.

Timperley, (1987) has reported on the water quality of New Zealand lakes. The major elemental ions calcium, magnesium, sodium, potassium, chloride, sulphate, and bicarbonate show regional differences depending on proximity to the coast, lithology of parent rock and lake origin (fluviatile, volcanic, glacial). The Taupo volcanic zone, for example, has unusual water quality because of geothermal activity: trace elements include arsenic, lithium, boron, mercury and tellurium. Arsenic, mercury and boron are potentially toxic. There is also a high phosphate loading that derives from pumice and ignimbrite lithology rather than from farming.

Suspended solids in low flow situations are usually less than 5 g/m3 (very much higher during floods) and the pH average is between 7.5 and 8.5, although in volcanic or forested catchments the water maybe acid with a pH of 4 or less.

The amount of oxygen in good quality water is dependent on temperature and the plant material present. Plants photosynthesise during the day but at night continue to consume oxygen, and with a temperature drop oxygen levels may fall below the normal 5 g/m3 — a similar scenario could happen in the atomosphere if we continue to use oxygen and destroy forest at present rates.

Elements such as phosphorous and nitrogen are important for aquatic plant growth. Both are present in many forms. In most waters phosphorous is less than 10 mg/m3 and nitrogen about 40 mg/m3. Nitrogen, however, can be as high as 5000 mg/m3 and is a key factor in dairy farming.

Rutherford *et al.,* (1987) reported the presence of phosphorous, nitrogen and oxygen in New Zealand rivers. Pastoral farming and related industries provide most of the phosphorous, nitrogen and organic material entering rivers. The quantity is about equal to that processed by urban systems.

## *Nitrogen and Phosphorous Loadings for Different Land Uses*

| Land use | Total P kg/ha/yr | Total N kg/ha/yr | Land use | Total P kg/ha/yr | Total N kg/ha/yr |
|---|---|---|---|---|---|
| Pasture | 0.29–1.6 | 4–14 | Pine Forest | 0.07–0.75 | 1–14 |
| Scrub | 0.12–1.2 | 6 | Indigenous Forest | 0.04–0.68 | 1.8–6.2 |

## *Nitrogen Input to Pasture and Nitrate Leaching*

| Inputs | kgN ha/yr | Losses | kgNO3 ha/yr |
|---|---|---|---|
| Rain | 2–5 | Light grazed pasture | 5 |
| Nitrogen fixation | 34–380 | Dry country | 10–25 |
| Urine dry sheep | 70–100 | Irrigated pasture | 70–100 |
| Urine intensive sheep | 130 | Ploughed cropland | 60–90 |

(Rutherford *et al.,* 1987)

Nitrogen leaches from animal faeces to groundwater. Small streams rapidly process nutrients with benthic (bottom dwelling) nitrifying bacteria and filamentous algae. Throughout the year the hydrological conditions of these streams affect the quantity of pollution as well as the nutrient discharge. These small streams are processors rather than transporters of nutrient.

New Zealand rivers have high rates of benthic mass transfer of nutrients and oxygen Rutherford *et al.,* (1987). The concentration of dissolved oxygen in the river is controlled by physical exchange with the atmosphere, biological response loss and photosynthesis gains.

Many organic substances can enter water and place a great demand on available oxygen as measured by BOD (biological oxidation demand). In clean water, the BOD is less than 1 g/m3; a rise to 5 causes concern. Milk, for example, has a BOD concentration of over 100 000 g/m3 and a small amount therefore, could adversely affect even a large river.

### *Point Source Nutrient and Organic Matter*

| Discharge to lake and rivers | Number | BOD5 | N | P |
|---|---|---|---|---|
| Sewage | 96 | 0.2 | 0.6 | 0.7 |
| Cowsheds | 7800 | 0.6 | 0.7 | 1.0 |
| Dairy factories | 23 | 0.3 | 0.1 | 0.2 |
| Meatworks | 18 | 0.7 | 0.6 | 0.6 |
| Pulp and paper | 6 | 0.3 | 0.2 | 0.1 |
| Piggeries | 220 | 0.2 | 0.4 | 0.8 |

Units in one million population equivalents

1pe = 77 g BOD5/capita/day

1pe = 11 g N/capita/day

1pe = 1.8 g P/capita/day

Metals are not normally present in dangerous concentrations in New Zealand water although mercury and arsenic can be significant in geothermal water (Smith, 1985). The many microbiological impurities that can enter water have been well documented by McBride *et al.,* (1992). Light entry into water controls photosynthesis, and changes in temperature can drastically alter biota by changing oxygen levels.

The biology and microbiology of New Zealand water are not well understood. Winterbourn, (1987) comments on invertebrate fauna. Fast flowing streams maintain an immature habitat in which it is difficult to measure competition and predation. Benthic communities are very resilient to large-scale disturbances e.g., flooding or logging when channel shape, cover and food sources are modified. Many species are endemic and have poorly sychronised life histories with long emergence periods. Predators include indigenous fish species that are carnivorous and non-selective feeders. Additional information on phytoplankton, zooplankton and habitat can be found in Viner, (1987).

Natural sources of impurities come from the atmosphere, rocks, geothermal activity and swamps. Mans' impact has been to change the land use from forest to other land uses and in so doing increases nutrients, decreases oxygen content, increases bacteria and raises water temperature (Timperley 1987).

Forestry operations increase sediment yields from 100 tonnes/km2/year (Tonkin & Taylor, 1977; Blake, *pers. com.*) to 300 tonnes/km2/year plus (Fahey & Coker, 1989) in the first year but this usually reduces significantly by year 3. Sediment is not usually a problem on flat land but cultivated hill sites may produce high sediment discharges during storms. On hill slopes, nitrogen and phosphorous removal may also be high. Riparian strips can be very effective in filtering these elements before they enter the waterway (Smith 1989). Concern about agricultural chemicals entering groundwater led Close, (1992) to investigate 82 wells in areas likely to be most under threat. Pesticide evidence was detected in nine; two exceeded very conservative international guidelines; the remainder were very low. However, these results do not show that groundwater is vulnerable.

Despite all scientific analyses water quality is pronounced good or bad if it does or does not meet a set of standards. Unfortunately, many people are not satisfied by this and claim to be able to assess water quality more accurately. Their hunch is more gut or holistic and difficult for the scientist to accept. Schwenk & Schwenk, (1989) described the "drop/picture" method: water samples are placed in a shallow bowl and treated with glycerine. Up to 30 drops of distilled water are added to the sample, and the ripple patterns photographed. Sketches of two drop pictures have been included. Sketch A is of water from a mountain stream in the black Forest, Germany. The water is high quality and naturally flowing, producing a well-developed rosette with a broad spread of vortex leaves. Sketch B is from the same stream but downstream of sewage and industrial effluent discharge. The drop disc shows a mere trace of rudimentary development with little differentiation. The formative capacity of this water is considered to be extinct.

This technique provides a very sensitive and holistic way of assessing water quality. Water moves in response to what is in it and what has been done to it. Observe the Waikato river from Lake Taupo to the sea to note its response.

## Recommendations

❶ Accurate and realistic definitions of organic and sustainability.

❷ Adoption of natural processes as a datum for development.

❸ Use the river catchment as a unit for resource management.

❹ Prepare organic procedures for land users.

❺ Reinstate hydrological networks and develop the drop method for measuring water quality.

❻ Advance soil/water/plant methodology to reinstate forests and stabilise water supply.

❼ Incorporate non-monetary costs in benefit/cost analyses.

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Winterbourn, MS (1987). Invertebrate Communities. In: Inland Waters of New Zealand Viner A B (ed). *DSIR Bulletin* 241, Wellington, New Zealand.

Woodward, L, Vogtmann, H (1996). The Challenges of Organic Agriculture-Outlook for the Future. In Fundamentals of Organic Agriculture. Ostergaard T V (ed). Proc 1. 11th IFOAM Conf., Copenhagen Denmark.

*Hella Bauer-Eden's interest in sustainable agriculture developed while working for a non-governmental development aid agency in Bonn, Germany in 1986-1988. Studying International Agricultural Development at Humboldt University in Berlin, Germany, she received broad training in plant and animal production, agricultural economics, policy and extension. Hella travelled extensively and gained practical farm experience working on dairy farms throughout New Zealand in 1993-94. After immigrating to New Zealand in 1995, Hella continued her training and involvement in the dairy industry. She graduated from Humboldt University, with a Master of Science in Agriculture in 1999, having completed her thesis 'Feasibility study of organic milk production in Nelson, New Zealand.' Through her long-term involvement in sustainable agriculture Hella has a wide-ranging network of national and international contacts with agricultural organisations, research institutes and individuals involved in organic farming and research.*

# 9 OVERSEAS AND INTERNATIONAL RESEARCH INSTITUTES CARRYING OUT ORGANIC RESEARCH

To provide a different type of information resource, contact details of institutes involved in organic research and useful web links have been included. This list is by no means comprehensive, but provides a good starting point to gather further information on organic research. The web links were all functional in August 2004.

## Germany

### *Institut für organischen Landbau (IOL)*

Rheinische Friedrich-Wilhelms-Universität Bonn
Direktor: Prof. Dr. Ulrich Köpke
Katzenburgweg 3, 53115 Bonn
phone: +49-2 28/73-56 15/16
fax: +49-2 28/73-56 17
e-Mail: IOL@Uni-Bonn.de
http://www.uni-bonn.de/iol

Accessed 24/8/04 but site hard to download, still downloading after 10 minutes….

Since October 1987 the Institute for organic farming has specialized in organic research and teaching. Research is aimed at developing and optimizing organic farming. The publications page is available at http://www.iol.uni-bonn.de/index2_e.htm

### *Institut für Pflanzenernährung*

Institute of Plant Nutrition
Rheinische Friedrich-Wilhelms-Universität Bonn
Karlrobert-Kreiten-Strasse 13
D-53115 Bonn
Phone: +49 -228 –732851
Fax: +49 -228 -732489
Email: ipe@uni-bonn.de
http://www.ipe.uni-bonn.de/indexe.htm

Accessed 24/8/04

Information provided at the home page of this institute of the University Bonn include a publication list, research topics and contact details of staff members involved in research.

### *Institut für Ökologie*

Abt. Landschaftsökologie Universität-GH Essen
Herr Prof. Dr. Wilhelm Kuttler
Universitätsstraße 5
45117 Essen
phone: + 49-2 01/1 83-27 34,    fax: +49-2 01/1 83-32 39

### *Institut für Pflanzenbau und Pflanzenzüchtung*

Institute of Crop Science and Plant Breeding
Justus-Liebig Universität Giessen
Institut für Pflanzenbau und Pflanzenzüchtung I
Leiter: Prof. Dr. Bernd Honermeier
FB 09 Agrarwissenschaften, Ökotrophologie und Umweltmanagement
Ludwigstr. 23, 35390 Giessen
Telefon: (+49) 641/99-37441
Telefax: (+49) 641/99-37449
http://www.uni-giessen.de/fbr09/ipz/pz/
**Accessed 22/08/04**

### *Institut für Pflanzenbau und Pflanzenzüchtung I*

Institute of Crop Science and Plant Breeding
Justus-Liebig Universität Giessen
Interdisziplinäres Forschungszentrum für Umweltsicherung (IFZ)
Leiter: Prof. Dr. Dr. h.c. Wolfgang Friedt
Heinrich-Buff-Ring 26-32
35392 Gießen
phone: +49-641-99 37421 oder 37431
Fax: +49-641-99 37429
E-mail: wolfgang.friedt@agrar.uni-giessen.de
http://www.uni-giessen.de/fbr09/ipz/pz/homeengl.html last updated 02/06/2004
Accessed 22/08/04

### *Fachgebiet Ökologischer Land- und Pflanzenbau*

Institute of organic farming and cropping systems
Universität Kassel Witzenhausen

Fachgebietsleiter: Prof. Dr. Jürgen Heß
Nordbahnhofstr. 1a
D-37213 Witzenhausen
phone: +49-5542 98-1565
fax: +49-5542 98-1568
e-mail: bruebach@wiz.uni-kassel.de
http://www.wiz.uni-kassel.de/foel/index_e.html
Accessed 18/8/2004
The site has been under construction since December 2002, it provides e-mail contacts and phone numbers.

### *Fachgebiet Ökologische Tierhaltung*

Department of Organic Animal Husbandry
Universität Kassel Witzenhausen
Fachgebietsleiter: Prof. Dr. Albrecht Sundrum
phone: +49-05542-981586
fax: +49-05542-981588
Nordbahnhofstr. 1a
37213 Witzenhausen
A list of departments is available at
http://www.uni-kassel.de/fb11cms/default.php?language=en&cPath=23
Accessed 18/08/04

### *Universität Hohenheim*

Fakultät IV - Agrarwissenschaften II
Agrarökonomie, Agrartechnik und Tierproduktion
Faculty IV, Agricultural Sciences II
Head of Faculty: Prof. Dr.sc.agr. S. Dabbert
Schloß, Speisemeistereiflügel
D-70599 Stuttgart
phone: +49-711/459-2322
fax: +49-711/459-4270
e-mail: agrarfak@uni-hohenheim.de
http://www.uni-hohenheim.de/i3ve/00000700/01246041.htm

The web page for organic production systems, http://www.uni-hohenheim.de/oelb/, is only available in German.
Accessed 18/08/04

### *Institut für Pflanzenernährung*

Institute for Plant Nutrition Institut 330
Head Prof. Dr. N. von Wirén

Universität Hohenheim,
Fruwirthstraße 20
D-70599 Stuttgart
Phone: +49-711/459-3504
fax : +49-711/459-3295
Email plantnut@uni-hohenheim.de
http://www.uni-hohenheim.de/i3ve/00000700/00097041.htm

Accessed 18/04/2004

'The purpose of the new series 'Organic Farming in Europe: Economics and Policy', published by the University of Hohenheim / Department of Farm Management, is to create an independent forum to provide in-depth and up-to-date information and to open a scientific debate.“

## *Institut für Biologisch-Dynamische Forschung*

Institute for Biodynamic Research
Brandschneise 5
D-64295 Darmstadt, Germany
phone: +49 - 6155 8421 - 0
fax:+49 - 6155 8421 - 25
email: info@ibdf.de
http://www.ibdf.de/

**Accessed 18/8/04**

The institute was established in 1950 as a registered non-profit association in Darmstadt, Germany; with a branch institute at the Dottenfelder Hof, a biodynamic farm in Bad Vilbel, Germany, and is a private, independent body. Projects are financed by project grants provided mainly by private foundations, to a smaller extent by public institutions.

**Current research focuses are:**
* Crop yield, product quality and soil fertility as a function of fertilization
* Breeding and seed preservation (cereals)
* Biological plant protection
* Optimizing the production and application of the biodynamic preparations
* Developing methods for food quality assessment

Results of a long-term fertilization trial: into yields, product quality and soil organic matter with long-term application of farmyard manure with and without biodynamic preparations compared to mineral fertilization are presented at this site.

The site has last been updated in August 2001. Publications available as PDF downloads at http://www.ibdf.de/pubs.htm include some English publications.

## *Institut für Biologisch-Dynamische Forschung*

Institute for Biodynamic Research
Holzhausenweg 7
D-61118 Bad Vilbel, Germany
phone: +49 - 6101 6385 fax: +49 - 6101 7948
email: spiess@ibdf.de

## *Bundesforschungsanstalt für Landwirtschaft*

Federal Agricultural Research Centre (FAL)
Bundesforschungsanstalt für Landwirtschaft
Bundesallee 50
38116 Braunschweig
phone: +49-531 596 - 0
fax: +49-531 596 - 1099
e-mail: info@fal.de
http://www.fal.de/en/index.htm?page=/en/forschung/
**Accessed 18/8/04**

"The FAL conducts research in the area of agricultural science and related disciplines. The organization publishes research results and cooperates internationally with other scientists and organizations. One purpose of the FAL is to obtain basic scientific knowledge to assist in political decisions on nutrition, agriculture, forestry and consumer issues."

## *Institut für ökologischen Landbau*

Institute of Organic Farming (OEL)
Head: PD Dr. Gerold Rahmann
Trenthorst 32
D-23847 Westerau
phone: +49-45 39/18 19-0
fax: +49-45 39/18 19-29
e-Mail: oel@fal.de

The institute for organic farming has opened in December 2000: http://www.oel.fal.de/en

"The new institute will actively initiate, institutionalise and consistently promote co-operative research in organic farming. Synergistic effects, as well as the conservation of resources through the avoidance of repetitive research, are the goal of co-operation and communication with other research institutions."

Information available includes English articles as PDF downloads.
http://www.oel.fal.de/en/index.htm?page=/en/research.htm

Accessed 6/10/03

### *Stiftung Ökologie & Landbau (SÖL)*

Foundation Ecology & Agriculture
Weinstrasse Süd 51,
D-67098 Bad Dürkheim
phone. +49-6322- 98 97 00
fax +49-6322-989701
e-Mail: info@soel.de
http://www.soel.de/english/index.html
Accessed 18/8/04

## Austria

### *Institut fur Ökologischen Landbau IFOL*

Universität fur Bodenkultur
Gregor Mendel-Haus
Gregor Mendelstr. 33
1180 Vienna, Austria
phone: + 43-1 47654-3750
fax: + 43-1 47654-3792
E-mail: bioland@edv1.boku.ac.at
http://www.boku.ac.at/oekoland/English.htm; Last update: 12.03.2003
Accessed 6/10/03

## Switzerland

### *Forschungsinstitut für Biologischen Landbau*

Research Institute of Organic Agriculture (FIBL)
Ackerstrasse
Postfach, 5070
Frick, Switzerland
Phone: +41-62 865 72 72

Fax: +41-62 865 72 73
e-mail: admin@fibl.ch
http://www.fibl.org/english/index.php Last Update 30.07.04

Accessed 18/08/04

The Research Institute of Organic Agriculture (FiBL, Switzerland) was constituted as a private foundation by organic farmers, scientists and politicians in 1973. It has established practice oriented agronomic and economic research, and is making new findings available to the organic farmers in Switzerland and abroad.

### *Organic Europe*

Research Institute of Organic Agriculture FiBL
Ackerstrasse
CH-5070 Frick
Tel: +41-62-865 72 72
Fax:+41-62-865 72 73
http://www.fibl.ch page available only in German
Contact: Helga Willer
Accessed 18/08/04

The Internet site http://www.organic-europe.net was set up in 2000. Within this project, an overview of organic farming in 25 European countries is given. The site contains an extensive database of contact details of people and institutes involved in organic research in Europe at http://www.organic-europe.net/address%5Fdatabase/

Accessed 18/08/04

### *Schweizerische Landwirtschaftliche Forschung*

Swiss Agricultural Research (SAR)
Research Institute of Organic Agriculture
Bernhardsberg
4104 Obervil
Switzerland
http://www.admin.ch/sar/en/index.htm
Accessed 6/10/03

Last modified: 05.02.04, the site provides valuable information in English.

There are six Swiss Agricultural Research Stations, which mainly deal with applied research. In Switzerland, basic research in agriculture is carried out by the Federal Institute of Technology as well as by certain Universities. Agricultural colleges for higher education and industries are also involved in applied research. Detailed information in English is available on research projects planned until 2003.

### *Institute of Plant Sciences*

Institute of Plant Science, Federal Institute of Technology LFW
Universitätsstr 2
CH-8092 Zürich
Switzerland
phone: +41 (0) 1 632 11 11
Fax: +41 (0) 1 632 10 37
Administrator: selsaad@ipw.agrl.ethz.ch
http://www.ipw.agrl.ethz.ch/index.html
Accessed 18/08/04
Some of the site seems dated, with last updates noted as 1997, 1999 and 2000.

Plant nutrition Group
ETH Zurich, Institute of Plant Sciences, Research Experimental Station
Eschikon 33
CH-8315 Lindau
Switzerland
http://www.pe.ipw.agrl.ethz.ch
Accessed 18/08/04

## Netherlands

### *University of Wageningen*

Department of **Ecological Agriculture and Society**
Head of the department: Prof Dr E.A. Goewie
Wageningen University
Building 527
Marijkehuis
Marijkeweg 22
6709 PG WAGENINGEN
THE NETHERLANDS
phone: +31-317-484006 fax: + 31 317 4 78213
e-mail: Eric.Goewie@wur.nl Office@biob.dpw.wag-ur.nl
http://www.wau.nl/nl/adressen
Accessed 18/8/04

The websites, last updated 06-10-2003, provide information in English, including abstracts of dissertations since 1918!

http://www.plant.wur.nl/default.asp?section=projects: a useful index of projects within the EU, with contact details.

Accessed 18/8/04

### *Alterra - Research Institute for the Green World (ALTERRA)*

Postbus 47
6700 AA Wageningen
The Netherlands
phone: +31-317 474700
fax: +31-317 419000
info@alterra.nl
http://www.alterra.wur.nl/UK/
Accessed 18/8/04

"Alterra: your environment is our concern. Alterra is *the* research institute for our green living environment. We offer a combination of practical and scientific research in a multitude of disciplines related to the green world around us and the sustainable use of our living environment. Flora and fauna, soil, water, the environment, geo-information and remote sensing, landscape and spatial planning, man and society: just a few of the numerous aspects of our green environment that Alterra focuses on.

Alterra is part of the Wageningen University and Research Centre concern. In research and education we closely co-operate with the school of Environmental Sciences from Wageningen University. The exchange of expertise and capacity and the match between fundamental and practical research in various projects give us a scientific advantage."

### *Louis Bolk Institute*

Hoofdstraat 24
NL 3972 LA Driebergen
Netherlands
phone: +31-343-52.38.60
fax +31-343-51.56.11
e-mail: info@louisbolk.nl
http://www.louisbolk.nl/e/index.htm
http://www.louisbolk.nl/e/publications/artbt/fr.htm
Accessed 6/10/03.

The institute, a private independent body, was established in 1950 as a non-profit association in Darmstadt, Germany; with a branch at Dottenfelder Hof, a biodynamic farm in Bad Vilbel, Germany.

"Connecting science with the practical domain, health and ethics for the good of life and quality."

- Independent research institute for organic agriculture, nutrition and health care

- Pioneering research based on anthroposophy since 1976
- Close collaboration with the sector in demonstration projects and participatory research
- Helping businesses with experiential knowledge
- International collaboration
- Project-based funding; projects supported by national and European governments, banks, farmers, endowment funds and business

Focuses of current research projects are:
* Crop yield, product quality and soil fertility as a function of fertilization
* Breeding and seed selection and preservation (cereals)
* Biological plant protection and methods for weed control
* Optimising the production and application of the biodynamic preparations
* Research in rhythms
* Composting of farmyard manure
* Developing methods for food quality assessment

## United Kingdom:

### *Organic Centre Wales*

Institute of Rural Studies,
University of Wales,
Aberystwyth, Ceredigion, SY23 3AL.
phone: +44-1970-622248.
fax: +44-1970-622238.
e-mail: organic@aber.ac.uk
http://www.organic.aber.ac.uk/index.shtml
Accessed 18/8/04

"The Organic Centre Wales is based at the University of Wales, Aberystwyth and run jointly by ADAS, Elm Farm Research Centre, The Institute of Grassland and Environmental Research (IGER), the Institute of Rural Studies (UWA) and the Soil Association".

### *Department of Soil Science*

School of Human and Environmental Sciences
University of Reading
Whiteknights

Reading
RG6 6DW
Telephone: +44-118 378 6557
Fax: +44-118 378 6660
Email: s.m.hawthorne@reading.ac.uk
http://www.soils.rdg.ac.uk/About%20us/about_us.htm last updated 11/08/04

Accessed 18/8/04

### *Greenmount College of Agriculture and Horticulture*

CAFRE – College of Agriculture, Food and Rural Enterprise, with campuses at Enniskillen, Greenmount and Loughry http://www.cafre.ac.uk/
Greenmount Campus
22 Greenmount Road, Antrim,
Co. Antrim, BT41 4PU
Northern Ireland
Phone: +44-289442 6601
Fax: +44-289442 6606
e-mail: enquiries@dardni.govt.uk
http://www.greenmount.ac.uk
Accessed 18/08/04

### *Department of Agriculture and Rural Development, N Ireland*

"The responsibilities of the Department of Agriculture and Rural Development include:

the development of the agricultural, forestry and fishing industries in Northern Ireland;
rural development in Northern Ireland; providing an advisory service for farmers;
agricultural research and education; providing a veterinary service and administration of animal health and welfare policies; responsibility to the Ministry of Agriculture, Fisheries and Food in the administration in Northern Ireland of schemes affecting the whole of the United Kingdom; the application of EU agricultural policy to Northern Ireland. "

http://www.dardni.gov.uk/index.htm last updated August 2004

Accessed 6/10/03.

### *Elm Farm Research Centre*

Hamstead Marshall
Nr Newbury
Berkshire RG20 0HR
phone: +44-1488-658298
fax: +44-1488-658503

e-mail:elmfarm@efrc.com
education@efrc.com research@efrc.com
OAS, Organic Advisory Service: oas@efrc.com
http://www.efrc.co.uk/ http://www.efrc.com/
Accessed 22/08/04

"Elm Farm Research Centre (EFRC) was founded in 1980 as an educational charity. Our aim is the development and promotion of organic agriculture as the most environmentally sound way of producing healthy food. As an educational charity, it is important for EFRC to get its information, knowledge and experience out into the public domain. This is not only achieved through the Organic Advisory Service and Education Services but also through written material - articles, scientific papers, contributions to books and our own Bulletin. Internationally, we collaborate with IFOAM, universities and research bodies, farmers' groups and individuals."

### *The Soil Association*

Bristol House
40 - 56 Victoria Street
Bristol BS1 6BY
UK
phone: +44-117 929 0661
fax: +44-117 925 2504
e-mail: info@soilassociation.org
http://www.soilassociation.org/SA/SAWeb.nsf/!Open
Accessed 22/8/2004

"The Soil Association, founded in 1946, is the UK's leading campaigning and certification organisation for organic food and farming. The Soil Association's organic symbol is the UK's most recognisable trademark for organic produce. Wherever you see it you can be sure that the food you have purchased has been produced and processed to strict and rigorous environmental and animal welfare standards. The Soil Association was founded by a group of farmers, scientists and nutritionists who were concerned about the way our food was produced. Over 50 years on we have grown in complexity and scope but at our core remains the fundamental link between healthy soil, healthy food, healthy people.

The site offers directories, links, contact details for groups, a library, bookshop and events calendar.

### *Institute of Grassland and Environmental Research (IGER)*

Aberystwyth
SY 23 3EB, United Kingdom
Phone:+44-1970-823 000

fax: +44-1970-828 357
Director of Research
Professor C J Pollock
Phone: +44-1970 823001
fax: +44-1970 820212
email: chris.pollock@bbsrc.ac.uk
http://www.iger.bbsrc.ac.uk/igerweb
Accessed 22/8/2004

The IGER's mission statement is "to undertake an integrated, cross-disciplinary programme of basic, strategic and applied research for a range of customers, emphasising grassland-related agricultural systems. The aim of our research is to enhance efficiency, to improve sustainability and to promote a viable partnership between the production of high-quality products and the effective management of the landscape."

The website offers ample information, contacts and links, a great resource for further exploration!

### *Henry Doubleday Research Association (HDRA)*

Ryton Organic Gardens
Coventry
Warwickshire
United Kingdom
CV8 3LG
Tel: +44 - 24 7630 3517
Fax: +44 - 24 7663 9229
Email: enquiry@hdra.org.uk
www.hdra.org.uk
**Accessed 22/8/04**

HDRA is Europe's largest organic membership organisation. It is dedicated to researching and promoting organic gardening, farming and food. "The organic approach to gardening and farming recognises that the whole environment in which plants grow is much more than the sum of its individual parts, and that all living things are inter-related and inter-dependent."

### *Department for Environment Food and Rural Affairs*

Nobel House
17 Smith Square
London
SW1P 3JR
Ph **+44 (0) 20 7238 6951**
helpline@defra.gsi.gov.uk
http://www.defra.gov.uk/
Accessed 22/8/04

## Sweden

### Sveriges Lantbruksuniversitet (SLU)

SLU (Swedish University of Agricultural Sciences)
P.O. Box 7070, SE-750 07 UPPSALA, SWEDEN
registrator@slu.se
Lennart.Salomonsson@cul.slu.se
http://www.slu.se/eng/index.html
Accessed 22/8/04

Provides a lot of information in English, links, contacts and more.

### *Centre for Sustainable Agriculture (CUL)*

Skilleby gard, S-153 91 JÄRNA, Sweden
Phone: +46 8 551 577 02
Fax: +46 8-551 577 81
sbfi@jdb.se
artur.granstedt@jdb.se lars.kjellenberg@jdb.se
http://www.jdb.se/sbfi/english/index.htm
Accessed 22/9/04

"The Centre for Sustainable Agriculture - CUL - is a focal-point for researchers and institutions interested in research, development, education and information related to ecological agriculture. CUL co-ordinates activities and promotes co-operation. It takes an active part in the work of developing interdisciplinary research methods."

### *Biodynamic Research Institute*

Skilleby,
S-15300 Jarna
Sweden
http://www.jdb.se/sbfi/english/Resprog/resprog02.html
Accessed 22/8/04

## United States

### *Appropriate Technology Transfer for Rural Areas (ATTRA)*

National Sustainable Agriculture Information Service
Hotz Hall - 4th Floor
1175 West Cleveland Fayetteville,
AR 72701 OR P.O. Box 3657
Fayetteville, AR 72702

+1-479- 442-9824
+1-479-442-9842 fax
rural@ncat.org
http://attra.ncat.org/
**Accessed 22/8/04**

"The National Sustainable Agriculture Information Service is the website of the Appropriate Technology Transfer for Rural Areas (ATTRA). The ATTRA Project, created and managed by the National Centre for Appropriate Technology (NCAT), is funded under a grant from the United States Department of Agriculture's Rural Business-Cooperative Service."

### *The Josephine Porter Institute for Applied Bio-Dynamics, Inc.*

P.O. Box 133
Woolwine, VA 24185-0133
phone: +1-276.930.2463
Fax: +1-276.930.2475
info@jpibiodynamics.org
http://www.jpibiodynamics.org/
Accessed 22/8/04

Makers of Biodynamic Preparations
The Josephine Porter Institute makes Biodynamic Preparations based on the original indications given by Rudolf Steiner. The Institute serves as a reliable source for biodynamic preparations for the beginning practitioner, and as an education centre for all biodynamic practitioners when they begin to make their own preparations.

### *Michael Fields Agricultural Institute*

W2493 County Road ES
East Troy, WI 53120
phone: +1-262 642-3303
fax +1-262 642-4028
mfai@MichaelFieldsAgInst.org
http://www.michaelfieldsaginst.org/
Accessed 22/8/04

"Michael Fields Agricultural Institute is a public non-profit education and research organization committed to promoting resource-conserving, ecologically sustainable and economically viable food and farm systems." Available through the website are quarterly newsletters, links and information.

### *The Kolisko Institute for Biodynamic Research and Education*

Post Office Box 15060
Santa Rosa
CA 95402

phone: +1-707-578-2085
fax: +1-707-578-2086
email: info@kolisko.org
http://www.kolisko.org (not accessible on 22/8/04)

Founded in 1999, the Kolisko Institute offers workshops, seminars, and advisory work. In association with New College of California's School of Alternative Agriculture it also (http://www.newcollege.edu/agschool) (not accessible on22/8/04) offers fully accredited BA and MA degrees in Biodynamic Agriculture. Specialized courses in biodynamic viticulture, composting, herbal sprays, backyard scale biodynamics and farm management are also offered. Research on the biodynamic preparations, composting and on herbal sprays is on-going.

"The Kolisko Institute is a non-profit organized solely for the purpose of promoting research and education in biodynamic agriculture. Our organization is named after Lili Kolisko, a woman who for years was a faithful researcher of the biodynamic suggestions given by Rudolf Steiner. We hope, in some modest fashion, to continue our biodynamic work in the spirit in which Ms. Kolisko took up hers."

### *The Centre for Integrated Agricultural Systems (CIAS)*

Centre for Integrated Agricultural Systems
1450 Linden Drive
University of Wisconsin
Madison, WI 53706
phone: +1-608-262-5200
fax: +1-608-265-3020
email: phaza@facstaff.wisc.edu
http://www.wisc.edu/cias/ The site has moved to www.cias.wisc.edu
New pages could not be accessed 22/8/04
http://www.wisc.edu/cias/pubs/index.html contains an online library
Not accessible 22/8/04

CIAS is a small sustainable agriculture research centre at the University of Wisconsin's College of Agricultural and Life Sciences. Created in 1989 to build UW sustainable agriculture research programs that respond to farmer and citizen needs, it aims to involve them in setting research agendas. This means that human relationships are at the core of everything we do.

### *Organic Farming Research Foundation*

P.O. Box 440, Santa Cruz, CA 95061
Phone: +1-831-426-6606
fax: +1-831-426-6670
http://www.ofrf.org/
Accessed 22/8/04

"The Organic Farming Research Foundation is a non-profit, tax-exempt foundation directed by certified organic farmers. We were founded in 1990 and our Board of Directors is composed of organic farmers, researchers and activists from around the nation. For decades organic farmers have produced just about every commodity under the sun using organic production methods, and have accomplished this objective without any institutional help. The Organic Farming Research Foundation is the only organization supporting organic farming grant-making research and advocacy in the nation.

Our Mission: To sponsor research related to organic farming practices, to disseminate research results to organic farmers and growers interested in adopting organic production systems, to educate the public and decision-makers about organic farming issues."

News bulletins are provided free of charge, and a Scientific Congress on Organic Agricultural Research (SCOAR) is organized annually.

## *Ohio State University Extension*

Department of Horticulture and Crop Science

2021 Coffey Road, Columbus, Ohio 43210-1044

http://hcs.osu.edu/

http://ohioline.osu.edu/agf-fact/ links to "Agronomy Facts Index"

Accessed 22/8/04

"This site is designed to serve as a knowledge bank and interactive learning centre on the care, cultivation, and utilization of plants from a commercial, consumer and academic perspective."

## *Sustainable Agriculture Network (SAN)*

Andy Clark, SAN Coordinator
Sustainable Agriculture Network
10300 Baltimore Ave.
Bldg. 046 BARC-WEST
Beltsville, MD 20705-2350
phone: +1-301-504-6425
Fax: +1-301-504-5207
san@sare.org
http://www.sare.org/htdocs/docs/SANandSARE.html
Accessed 22/8/04

SAN is the communications and outreach arm of the Sustainable Agriculture Research and Education (SARE) program. SAN is dedicated to the exchange of scientific and practical information on sustainable agriculture systems using a variety of printed and electronic communications tools.

## *Sustainable Agriculture Research and Education (SARE)*

Valerie Berton, Communications Specialist
USDA-SARE
10300 Baltimore Ave., Bldg. 046
Beltsville, MD 20705
phone: +1-301 504-5230

Fax: +1-301 504-5207
vberton@umd.edu
http://www.sare.org/
http://www.sare.org/about/contacts.htm
Accessed 22/8/04

SARE is a U.S. Department of Agriculture-funded initiative that sponsors competitive grants for sustainable agriculture research and education in a regional process nationwide.

### *Alternative Farming Systems Information Center (AFSIC) at the US National Agricultural Library,*

10301 Baltimore Ave.
Room 132, Beltsville
MD 20705-2351
Phone: +1- 301-504-6559; TDD: +1-301-504-6856
FAX: +1-301-504-6409
afsic@nal.usda.gov
http://www.nal.usda.gov/afsic/
Accessed 22/8/04

"We specialize in identifying and accessing information related to alternative agricultural enterprises and crops as well as alternative cropping systems." There is a list of searchable sites and databases on a sub-page http://www.nal.usda.gov/afsic/agnic/agnic.htm#search
Accessed 22/8/04

### *The Rodale Institute*

611 Siegfriedale Road
Kutztown, PA 19530-9320 USA
Phone: +1-610-683-1400
Fax: +1-610-683-8548
info@rodaleinst.org
http://www.rodaleinstitute.org/home.html
Accessed 22/8/04

"The Rodale Institute works worldwide to achieve a regenerative food system that improves environmental and human health. We believe that Healthy Soil = Healthy Food = Healthy People®, its a matter of human survival."

http://www.biodynamics.com/groups.html is the website of the Biodynamic Farming and Gardening Association Inc. in San Francisco and provides links and information about biodynamics in the US.

Accessed 22/8/04

## Canada

### *Ecological Agriculture Projects*

McGill University (Macdonald Campus)
Ste-Anne-de-Bellevue, QC,  H9X 3V9 Canada
phone: +1-514-398-7771
fax:      +1-514-398-7621
e-mail: eapinfo@macdonald.mcgill.ca
http://www.eap.mcgill.ca/General/library.htm
Accessed 22/8/04

"Ecological Agricultural Projects (EAP) has a large resource centre, containing one of the world's best collections of materials on sustainable food and agriculture systems. The EAP database can be searched via the Internet to identify references on specific subjects, and see what articles prepared by EAP are available. Sustainable Agriculture 'Virtual Library' offers full text or excerpts of thousands of useful documents, including the complete catalogue of EAP publications, other key articles from the collection, back issues of selected farm magazines and newsletters, annotated guides to significant literature, syntheses, abstracts, and linkages to other pertinent Internet sites."

## Australia

### *Rural Industries Research & Development Corporation (RIRDC)*

Level 1, AMA House,
42 Macquarie Street
BARTON ACT 2600
PO Box 4776, KINGSTON ACT 2604
phone: +61-2-6272 4539
fax: +61-2-6272 5877
e-mail: rirdc@rirdc.gov.au
http://www.rirdc.gov.au/
Accessed 22/8/04

This site provides information on current and completed research projects and projects, with project title, objectives and contact details for the researcher involved. Although it seems as if organic section of site http://www.rirdc.gov.au/99comp/org1.htm has last been updated in September 1999 (main site in September 2003) the information provided is worth exploring. Accessed 22/8/04

## International:

### *International Federation of Organic Agriculture Movements IFOAM*

IFOAM Head Office
c/o Ökozentrum Imsbach
D-66636 Tholey-Theley
Germany
phone: +49-6853-919890
fax: +49-6853-919899
e-mail: HeadOffice@AEA-ifoam.org
webmaster@ifoam.org
http://www.ifoam.org/
Accessed 22/8/04

"Leading, uniting and assisting the organic movement in its full diversity. Our goal is the worldwide adoption of ecologically, socially and economically sound systems that are based on the principles of Organic Agriculture."

"The federation's main function is coordinating the network of the organic movement around the world. IFOAM is a democratic federation and grass root oriented."

### *Inter-Departmental Working Group on Organic Agriculture Food and Agriculture*

Organization of the United Nations
Secretary Nadia Scialabba
Via delle Terme di Caracalla
00100 Rome, Italy
phone: +39-3906-57056729
fax: +39-3906-57053369
e-mail: nadia.scialabba@fao.org
http://www.fao.org/ http://www.fao.org/sd/2003/en0102_en.htm
Accessed 22/8/04

### *Organic-research.com*

organic-research.com is an online community for organic farming and food, developed by CABI *Publishing*. CABI *Publishing* aims to provide impartial information of high quality, recognizing worldwide interest in organic farming and related sustainability issues. Access to organic-research.com is restricted to subscribers. Individual visitors to organic-research.com may register for a free personal 24 hours trial.

www.organic-research.com Accessed 22/8/04

# Further organic contacts:

## *Agriculture Network Information Center*

http://laurel.nal.usda.gov:8080/agnic/
Contact agnic@agnic.org
Accessed 22/8/04

"The Agriculture Network Information Center (AgNIC), is a voluntary alliance of the National Agricultural Library (NAL), land-grant universities and other agricultural organizations, in cooperation with citizen groups and government agencies. AgNIC focuses on providing agricultural information in electronic format over the World Wide Web via the Internet."

## *European Universities' Consortium for a Common Curriculum in Ecological Agriculture*

The Curriculum Development in Ecological Agriculture Consortium, established in 1994, has currently 10 participating universities; three of them (in the United Kingdom, Denmark and Germany) are teaching the common semesters for the Ecological Agriculture specialisation at Bachelor's level. It is envisaged that additional universities will become involved in teaching the specialisation, and that continuing curriculum development work will lead to a Master's level common programme in Agroecology.

The following website contains details of participating universities and further web links: http://www.irs.aber.ac.uk/research/Organics/training/consort.html
Accessed 22/8/04

## *The European Network for Scientific Research Coordination in Organic Farming ENOF*

ENOF's main objective is to put in contact and establish collaborations between the Organisms or European Entities that work on Education, Research, Experimentation, Demonstration or Diffusion of Organic Farming Techniques. One of the most important results from ENOF was the elaboration of a database on Research in Organic Farming in Europe.

http://www.cid.csic.es/enof
Accessed 22/8/2004

*Brendan Hoare (M.App. Sci.), who wrote the beginning of this chapter, is currently Senior Lecturer in Sustainable Hortecology and Design at UNITEC Institute of Technology, Auckland, former President of the Soil and Health Association of New Zealand, Co-convenor of Aotearoa New Zealand (OFANZ) and a Board member of BioGro.*

# 10 ORGANIC ORGANISATIONS IN NEW ZEALAND

Apart from the many polytechnics and other training institutions that now provide education on organic farming, the main sources of information for farmers and growers have been: The Soil and Health Association, and the Bio Dynamic Farming and Gardening Association, and their branches and regional groups. Bio-Gro NZ, while principally a certification organisation, also provides some information, and the Permaculture Institute provides information on design of systems relevant to organic farming systems.

Information about the Bio Dynamic Farming and Gardening Association and its resources is provided on this website. Information about the Soil and Health Association can be found on its website: www.soil-health.org.nz. The following review has been provided by Brendan Hoare, former President of the Association.

## The Soil and Health Association of New Zealand Inc.

Founded in 1941, the Soil and Health Association of New Zealand Incorporated was originally named The Compost Club and has since gone through several name changes. The organisation has 60 years of publication history, its first publication was March 1942.

'To the Rescue of the Soil'[1] was the title of the first editorial that clearly laid out the Association's maxim 'healthy soil — healthy food — healthy people.' Sustainable land management and a holistic approach to improving the whole production system have always been central from early to present writings. Methods for restoring soils, the importance of humus and herb leys, vermiculture, methodologies of production, soil biological practices, the importance of weeds in the biological system, connections with human health have been common themes central to the philosophy over the last 60 years. The written documentation has always been a mixture of recent scientific studies, observations from practitioners, and relevant articles from international publications.

Emphasis has also been placed on the value of all producers, including domestic and small-scale ones. Central to the work of the Association is the importance of the home garden for family health and education. Regular sections of the journal have demonstrated how home gardeners can grow food in any conditions and on all types of soil throughout the world, but especially in New Zealand. The management practices of home gardening have always been espoused as a social imperative, central to family health and well-being.

The Association has for a long time considered itself the gatekeeper and conscience of Organics in New Zealand. It has been instrumental and innovative in the establishment of broad-scale composting, the creation of BIOGRO New Zealand, and the initiation of the vision of New Zealand being an Organic Nation by 2020[2].

[1] Chapman, G. Vol. 1 No. 1 1942. *'To the Rescue of the Soil.'* Compost Club Magazine.

[2] Hoare, B., Watts, M. & Cowperthwaite, V. Vol. 58, No. 6 *'Organic 2020.'* Soil and Health.

It has also offered New Zealand some of the earliest documented critiques of land use management practices. Past President and mayor of Auckland, Sir Dove Myer Robinson, was as early as 1950, writing and offering the use of municipal composting[3]. Eutrofication of New Zealand Lakes[4], what the science of ecology means to farming[5], the effects Genetic Engineering will have on Organics[6] and commentary of landscape ecostructures for sustainable societies[7] are some examples of other critiques and commentary.

The Association also holds historical documentation and commentaries on controversial practices and issues such as charcoal as fertiliser[8], sewage sludge as compost[9], the hazards of atomic radiation in relation to agriculture[10], issues pertaining specifically to Maori[11]and mad cow disease[12].

When required, the Association produces 'special issues' relating to pertinent social issues. Three of the most prominent special issues are 'Conservation and the Environment' (1971), The Self Help Cancer Cure Book' (1997) and the 'GE Issue' (1999).

Apart from the use of artificial fertilisers, one of the most persistent themes of the Association has been the drive to remove artificial chemicals and biocides from our environment. Concern about the use of DDT was expressed as soon as it became common practice, and articles were written as early as 1959[13]. This concern and advocacy role has continued through to today .

## *Regional Groups*

| | | |
|---|---|---|
| Auckland | Ian Fielding | 09 298 8693 |
| Taranaki | Deborah Schrider | 06 756 7453 |
| Palmerston North | Margaret Mc Kenzie | 06 358 2535 |
| Levin | Winifred Bourn | 06 368 6701 |
| Mid Canterbury | Bev Cameron | 03 308 2041 |
| | Juliet Hooper | 03 308 8950 |
| Invercargill | Elma Davidson | 03 217 9753 |

## *National Office*

PO Box 36-170, Northcote, Auckland 9
Ph: 09-419 4536, Fax 09-419 4556
Info@organicnz.pl.net

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[3] Robinson, D. M. Vol. 9, No. 1 1950. *'A Milestone in the History of New Zealand.'* Compost Society Magazine.
[4] Mitchell, S.F. Dr. June July 1971. *'Eutrophication of New Zealand Lakes.'* Soil and Health.
[5] Stanton Hicks, Sir C. Dr. Aug Sept 1971. *'Ecology and Us.'* Soil and Health
[6] Harvey, G. Autumn 1988. *'Bio-Technology.'* Soil and Health.
[7] Tane, H. Vol. 58, No. 5. *'Landscape Ecostructures for Sustainable Societies.'* Soil and Health
[8] Marian, S. Vol. 9, No. 1 1950. *'Charcoal as Fertiliser.'* Compost Magazine.
[9] Wright, J. Spring 1983. *'Treated Sewage.'* Organic Growing.'
[10] Morris, D. Aug–Sept 1971. *'The Hazards of Atomic Radiation.'* Soil and Health.
[11] Taylor, A. & Patrick M. Winter 1988. *'Water, Waste and Waitangi.'* Soil and Health
[12] Wheeler, C. April/May 1996. *' Mad Cows – What are they trying to tell us.'* Soil and Health.
[13] Editorial. Vol 18 No. 4 1959. *'Concern at DDT Contamination.'* Compost Society Magazine.

## Bio Dynamic Farming and Gardening Association

The following are products and services available to the Association members. Some are also sold to non-members.

- Magazine: Harvests. The Association's magazine Harvests covers different aspects of biodynamics in New Zealand.
- Research and Development services.
- Advisory services
- Biodynamic Calendar
- Biodynamic Preparations
- Lending Library
- New Books
- Demeter Certification
- Seed Bank
- Bio Dynamic Opportunities in Training: Practical Experience

  A number of Association members are prepared to offer interested people the opportunity of working experience on their properties. Period of stay is negotiable, with accommodation and board usually exchanged for work.

### Regional Group Contacts

| | | |
|---|---|---|
| Northland - | Robert and Janet Browne, | Ph. 09 433 9690 |
| Auckland South | - Ian & Kate Buckingham, | Ph. 09 233 6006 |
| Auckland North | - Bernadette Blair, | Ph. 09 415 9044 |
| Bay of Plenty | - Peter and Gill Bacchus, | Ph. 07 542 1914 |
| Waikato | - Tanja Benthien, | Ph. 07 872 2545 |
| Gisborne | - Jack Wanklyn, | Ph. 06 862 5484 |
| Hawke's Bay | - Cleone Armon, | Ph. 06 878 3128 |
| Wairarapa | - Frank van Steensel, | Ph. 06 304 8116 |
| Wanganui | - Col Priddle, | Ph. 06 343 7943 |
| Manawatu | - Joanne and Greg Turner, | Ph. 06 329 0943 |
| Kapiti Coast | - Hannelore Geuther, | Ph. 04 235 6275 |
| Wellington | - Judy Randall, | Ph. 04 589 5366 |
| Motueka | - Dieter Proebst, | Ph. 03 528 8718 |
| Westland | - Terry Duthie, | Ph. 03 736 9321 |
| Canterbury | - Peter White, | Ph. 03 314 6886 |
| South Canterbury | - John Guthrie & D. Davaux, | Ph. 03 689 4880 |
| Central Otago | - Nick Mills, | Ph. 03 443 8084 |
| Dunedin | - Cathrin Stewart, | Ph. 03 473 0303 |
| South Otago | - Warrick Thomson, | Ph. 03 418 3357 |

### National Office

David Wright PO Box 39045, Wellington
Telephone: 04 589 5366 Fax: 04 589 5365
Email: info@biodynamic.org.nz Website: www.biodynamic.org.nz

## Organic Products Exporters of New Zealand Inc (OPENZ)

OPENZ – Organic Products Exporters of NZ Inc. was formed to encourage and support companies and organisations, who have an interest in the New Zealand organic export industry. PO Box 8640, Christchurch. Ph 03 348 0979, Fax 03 348 1867.

The website incudes a directory of research and information reports

Email:info@organicsnewzealand.org.nz Website: www.organicsnewzealand.org.nz

## Agriquality New Zealand Ltd

Agriquality through its certification business provides organic certification to the AgriQuality Organic Standard. International recognition through Certenz accreditation ISO 65.

David Brown PO Box 307, Pukekohe
Telephone: 0 9 237-1807
Fax: 0 9 238-3757
Email: brownd@agriquality.com
Website: http://www.agriquality.co.nz

## Bio-Gro New Zealand

Provides organic certification since 1983. IFOAM accredited.

Kaye McAulay PO Box 9693, Marion Square, Wellington.

Telephone: 04 801 9741

Fax: 04 801 9742

Email: KayeM@bio-gro.co

Website: www.bio-gro.co.nz

Organic Farms NZ
Small growers, pod based, affordable regional certification scheme.
Contact Soil & Health Assoc of NZ Inc (see above)

## Te Waka Kai-ora

**Chairman**: Percy Tipene R.D.3 Kaikohe
Telephone 09-401-4837
Mobile: 027 2559362
Email: tipenep@xtra.co.nz.

Sec /Tre Tanima Bernard tani@ihug.co.nz

**Regional Contacts:**

Cherryl Smith cw.smith.whanganui@xtra.co.nz

Malibu Hamilton cleanearth@email.com

| | |
|---|---|
| Linda Lee | linda@pukaki.net.nz |
| Mere Takoko | mtakoko@nz.greenpeace.org |
| Hira Hunapo | hira@aotearoa.gen.nz |
| Graham Harris | graham.harris@openpolytechnic.ac.nz |
| Tamatea Kopua | manawag@hotmail.com |
| Maanu Paul | mgpaul@wave.co.nz |
| John Reid | john.amy.reid@paradise.net.nz |
| Craig Pauling | craig.pauling@ngaitahu.iwi.nz |
| Tawhai McClutchie | eastcapeorganics@xtra.co.nz |

## Federated Farmers of New Zealand (Inc)

Farm/rural producer organisation

**President:** Tom Lambie PO Box 715, Wellington
Telephone: 04 473 7269
Fax: 04 473 1081
Email: receptionwgton@fedfarm.org.nz
Website: www.fedfarm.org.nz

## Permaculture Institute of New Zealand

Permaculture National organisation : advocates and promotes training in sustainable design and the practises involved in maintaining and developing sustainability and beyond.

| | |
|---|---|
| Permaculture in New Zealand, | P O Box 9376 Marion Square,Wellington |
| Contact Sylvia Frean | 04 973 5334 |
| sylviafrean@yahoo.com.au | www.permaculture.org.nz |

Runs courses, sells books and develops materials for teaching environmental education including permaculture design . Networks with many organisations about sustainability.

| | |
|---|---|
| Living Lightly | 66 Ngamotu Rd, Taupo |
| courses@livinglightly.org.nz | www.livinglightly.org.nz |
| contact Jo Pearsall or Bryan Innes | 07 377 8910 |

Runs national events for sustainability and networks with other organisations on all issues of sustainable development in NZ and elsewhere.

| | |
|---|---|
| Ecoshow Charitable Trust | 66 Ngamotu Rd, Taupo |
| www.ecoshow.co.nz | ecoshow@ecoshow.co.nz |

## New Zealand Organic Kiwifruit Growers Association.

Leo Whittle PO Box 330, Te Puke

Telephone: 07 573 8471

Email: whittle@hyper.net.nz

## Organic Pipfruit Growers NZ Inc.

Heidi Stiefel

Telephone: 06 835 4850

mobile: 021 336 791

email: heidi.stiefel@xtra.co.nz

## Organic Dairy Producers Group Incorporated

exists to;-

- Promote organic dairy farming as a viable sustainable way of farming, financially, environmentally and personally.
- Provide a forum to allow members to exchange ideas and information with other organic farmers.
- Be a voice for organic dairy farmers in NZ where ever that role might be needed.
- Assist members wherever possible.

Contact;

| | |
|---|---|
| Ray & Jenny Ridings | 15 Ridings Rd, RD 1 Paeroa |
| Telephone: | 07 867 6809 |
| Fax: | 07 867 6899 |
| Mobile: | 025 290 8109 |
| Email: | ridings@wave.co.nz |

## Regional Groups

## Canterbury Commercial Organic Group

| | |
|---|---|
| Mary Ralston, | Back Track, RD 12, Rakaia |
| Telephone | 03 302 9202 |
| Email | kem@xtra.co.nz |

## Central Districts Organic Growers Group

Pauline Blaikie RD Rewa, Feilding

Telephone: 06 328 6842

Fax: 06 328 6872

## Far North Organic Growers and Producers Association

Seed, group, certification

Terry Higginson 09 408 4218 or

Verner Krieger 09 408 4354

## Tairiwhiti Organic Incorporated Society

Collective research, advocacy, market research, developing infrastructures for organic farming. Growers, processors, exporters, education / training advisors.

Tracey Tangiharere PO Box 404, Gisborne

Telephone: 06 862 8541 021 362 833

## Horowhenua Organic Group (HOGS)

Tony Robinson

Telephone: 06 368 9265

## Southern Region Commercial Growers

Ian Sloan Mataura Island, No.1 RD, Wyndham

Telephone: 03 206 4907

## Top of the South Organic Producers

Hugh Webb and Vicki Carlisle RD 1, Takaka, Golden Bay

Telephone: 03 525 8729

## Wairarapa Organics

Producers and consumers group promoting organics in the Wairarapa

Frank van Steensel PO Box 19 Greytown

Telephone: 06 3048116

## Research & Development Organisations and Scientists

This list includes some research organizations and scientists with an involvement in organic research and development.

| | |
|---|---|
| Ag Research | http://www.agresearch.co.nz/ |
| EcoAgriLogic | www.ecoagrilogic.co.nz |
| Landcare Research | www.LandcareResearch.co.nz |
| Lincoln University | http://www.lincoln.ac.nz/ |
| Massey University Institute of Natural Resources | www.massey.ac.nz |
| Organic seed NZ | colinwalker@organicseed.co.nz |
| Unitec New Zealand | www.unitec.ac.nz |
| University of Otago, | http://www.otago.ac.nz/nzpg/csafe |

| | | |
|---|---|---|
| Peter Bacchus | Soil, biodynamic consulting | pbacchus@actrix.co.nz |
| Gill Bacchus | Soil, food quality | gillcole@actrix.gen.nz |
| Dr Troy Baisden | Soil ecology | BaisdenT@LandcareResearch.co.nz |
| Dr Diane Bourn | Food Quality | diane.bourn@stonebow.otago.ac.nz |
| Assoc Prof Hugh Campbell, | CSAFE, Otago Univ. | hugh.campbell@otago.ac.nz |
| Dr John Clearwater | orchard entomology | j.clearwater@xtra.co.nz |
| Dr Ross Cullen | Commerce Division, | cullenr@lincoln.ac.nz |
| Murray Doak, | stats & monitoring issues | DoakM.ADCPO.ADC@maf.govt.nz |
| Scott Fraser | soil microbiology | scottfa@callplus.net.nz |
| George Fietje | Technical Manager | gfietje@livingearth.co.nz |
| Dr Alf Harris | indigenous, post-petroleum agroecology | a.harris@waikato.ac.nz |
| Dr Allan Hewitt | soil databases | hewitta@landcareresearch.co.nz |
| Rob Hill | | rhill@biodiscovery.co.nz |
| Prof. Stuart Hill | organic systems | s.hill@uws.edu.au |
| Brendan Hoare | Unitec Hortecology Sanctuary | 09 8154321 x 7294 |
| Dr Tim Jenkins | Microbiology, soil fertility | tuss@paradise.net.nz |
| Holger Kahl | CPIT Education/Training and Research | kahlh@cpit.ac.nz |

Dr Terry Kelly organic systems education T.C.Kelly@massey.ac.nz

Dr Gavin Kenny organics and climate change gavinkenny@clear.net.nz

Dr Peter Kettle Science policy Peter.Kettle@maf.govt.nz

Dr Maggie Lawton, Operations Manager lawtonm@landcareresearch.co.nz

Dr Alan Palmer, Soil mapping, and evaluation A.S.Palmer@massey.ac.nz

Dr Roger Parfitt, Soil N, soil P, soil OM ParfittR@landcareresearch.co.nz

Dr Don Pearson Biological Husbandry Unit thebhu@quicksilver.net.nz,

Nick Pyke Foundation for Arable Research PykeN@far.org.nz

Dr Anis Rahman Weed Management anis.rahman@agresearch.co.nz

Nick Roskruge Maori Resource Studies N.Roskruge@massey.ac.nz

Duncan Stuart FMRSNZ duncan@kudos-dynamics.com

Bruce Snowdon HBY Heinz Wattie bruce.snowdon@heinz.co.nz

Prof. Haikai Tane Center for Catchment Ecology: taneh@watershed.net.nz

Greg Tate Crop Health Services gtate@inhb.co.nz

Frank van Steensel agri-ecological R & D info@ecoagrilogic.co.nz

Colin Walker Organic Seed NZ sunlight@orcon.net.nz

Dr Meriel Watts Food Safety; policy m.watts@organicnz.pl.net

Dr Gregor W Yeates Soil Zoologist YeatesG@LandcareResearch.co.nz

# Web Directories

**Website:** http://www.organic-register.com

— online directory with over 1000 organic producers and products in New Zealand. For details of many organic products, services, research and certifying agencies. A hard copy is also available from:

NZ Organic Register, 95 Kahuterawa Rd, RD4, Palmerston North.

Organic Pathways

**http://www.organicpathways.co.nz**

The Organic Directory NZ will help you find organic products, businesses and organisations. It includes organic producers, retailers, processors and services as well as organic groups and organisations

# APPENDIX 1: A TABULAR MODEL OF ECOLOGICAL SUCCESSION OF THE AUTOGENIC, AUTOTROPHIC TYPE

| | Trend in ecogological development | | |
|---|---|---|---|
| | **Early stage** | → | **Climax** |
| | **Youth** | → | **Maturity** |
| **Ecosystem characteristic** | **Growth** | → | **Steady state** |
| **Community Structure** | | | |
| Species composition | Changes rapidly at first, then more gradually (relay floristics and faunistics) | | |
| Size of individuals | Tends to increase | | |
| Species diversity | Increases initially, then stabilizes or declines in older stages as size of individuals increases | | |
| Total biomass (B) | Increases | | |
| Non-living organic matter | Increases | | |
| **Energy Flow (Community Metabolism)** | | | |
| Gross production (P) | Increases during early phase of primary succession; little or no increase during secondary succession | | |
| Net community production (yield) | Decreases | | |
| Community Respiration (R) | Increases | | |
| P/R ratio | P > R to P = R | | |
| P/B ratio | Decreases | | |
| B/P and B/R ratios (biomass supported/unit energy) | Increases | | |
| Food chain | From linear chains to more complex food webs | | |
| **Biogeochemical Cycles** | | | |
| Mineral cycles | Become more closed | | |
| Turnover time and storage of essential elements | Increases | | |
| Internal cycling | Increases | | |
| Nutrient conservation | Increases | | |
| **Natural Selection and Regulation** | | | |
| Growth form | From r-selection (rapid growth) to K-selection (feedback control) | | |
| Life cycles | Increasing specialization, length, and complexity | | |
| Symbiosis (living together) | Increasingly mutualistic | | |
| Entrophy | Decreases | | |
| Information | Increases | | |
| Overall efficiency of energy and nutrient utilization | Increases | | |

Adapted from Odum, (1997)

# APPENDIX 2: PARADIGM SHIFT IN SOIL SCIENCE AND SOIL MANAGEMENT

Until recently, the emphasis in (soil) science and farming methods was on component research leading to materialistic, reductionistic, specialist approaches, but views are changing about soil science and soil management. The characteristics of this (technological) approach are compared with those of an ecological approach in Table 2, below. The table is a polarizing generalization but it shows paradigm shift, with an increasing trend in both soil science and soil management towards the ecological view.

Table 2. Generalized description of characteristics and views on soils: technological versus ecological technological view (EXTREME) ecological view (EXTREME).

| | |
|---|---|
| **General scientific characteristics** | |
| Materialistic-Physical/chemical reality is matter and dead | Metaphysical + living + organic |
| Reductionistic: reality consists of building blocks that can be known individually | Holistic: complex systems that are more than the sum of system units/components |
| Analytical approach | Total/synthetical approach: analysis and synthesis, phenomenology |
| **Soil fertility characteristics** | |
| Soil = substrata | Soil ecosystem, living 'organism' |
| Dead, static, replaceable | Living, under development, unique |
| Fertility is the sum of separate units | Fertility consists of inseparable/integrated components |
| Physical and chemical soil fertility | They are different but not separate |
| Soils are controllable in analytical units | Soils are manageable by steering living processes |
| Elements, ions, fractions | e.g., soil formation, humification, mineralisation, management of soil live |
| **Soil fertility in practice** | |
| Replacement | Stimulation, management |
| Replacement of soil processes by external inputs | Stimulating and steering of soil processes |
| Feeding plants | Feeding soil-life |
| Use of soluble, inorganic fertilizers | Organic manures |
| Emphasis on N, P, K-compounds | Emphasis on C-compounds in soil |
| Short-term planning and decision making | Long-term planning and decision making |
| Pressured by farm economics | Sustainable production systems, macro economy |
| Input/output | Throughput |
| What it costs, what is the profit | How the system functions, stimulating internal re-cycling, increasing the 'buffering' of the system |
| Keeping ratio input/output small | |

# APPENDIX 3: COMPOSTING AND MAINTENANCE OF SOIL FERTILITY AND STRUCTURE

Maintenance of the organic matter content of the soil is crucial for all sustainable farming including orchards and dairy farms. Fresh organic matter added to the soil is easily degraded by soil biological activity. The end product of organic matter breakdown is stable humus. This process is always dependent on the matter from which it is broken down, the environmental conditions under which it is processed and the microbes involved in the decomposition. This decomposition process can be managed by composting.

Compost and humus have the potential to provide a sustainable basis for primary production that will lead to an optimum production system especially on marginal soils. Addition of compost has the following effects:

- increase in C.E.C , N, S and to a lesser extent P content
- stabilization of and slow release of nutrients
- improved soil structure with improved moisture retention and improved aeration
- reduction in pests and harmful organisms and neutralization of toxins
- levelling of extremes of (soil) temperature and pH
- stimulation of soil life, biota diversity and complexity of soil food web
- increased soil weathering and breakdown of soil minerals.

Compost quality depends on the composting materials, method and conditions. The ratio of carbon to nitrogen (C/N ratio) affects the process and product. The end product can serve different purposes depending on the requirements of the crop and/or soil.

**Table 1: Organic matter** (adapted from v.d. Werff (1992)

| | % decomposition per year | Soil Structure | Plant nutrients |
|---|---|---|---|
| fresh organic matter (high C/N ratio) | 50–80% | + | +++ |
| dynamic humus/feeding humus | 5–50% | ++ | ++ |
| stable humus (C/N ratio~ 10) | 2–5% | +++ | + |

Fresh organic matter has a breakdown rate of 50–80% after the first year of application. Stable humus breaks down much more slowly –2-5% a year. This means that fresh organic matter contributes to the nutrient availability and the moisture availability of the soil but does little to improve the structure of the soil.

Next to the breakdown and synthesis of organic compounds there is the *sanitary* effect of composting. For this aspect, relatively high temperatures and the length of time of composting are important. Most weed seeds, fungi spores and bacteria are killed at a temperature of 55–60$^{o}$ Celsius. Long term composting leads to the destruction of weed seeds and pathogens by antibiotics and other physiological/biotic substances. This can be of major importance with horticultural wastes and weeding wastes. However, there are also advocates (Viktor Schauberger:The Fertile Earth (translated by Calum Coats) of the cold composting process, which favours different organisms, such as worms.

Length of time, the temperature of composting, and the C/N ratio of the original material are the main factors influencing the outcome. Starting with organic matter that has an average C/N ratio of 33/1 makes it theoretically possible to capture all the nitrogen from the organic matter without loss to the air[1], as sufficient C is available to supply maintenance and growth and reproduction for micro-organisms. A C/N ratio lower than 33/1 increases nitrogen losses to the environment. Research is underway in Europe comparing the effectiveness of various compost coverings to prevent nitrogen losses.

Since air, water, neutral pH, temperature and food supply (C/N ratio) are important to composting (micro) organisms, these should be managed appropriately. For instance, high moisture contents create anaerobic conditions, stimulating anaerobe micro-organisms. The by-products of anaerobic decomposition are (if excessive) toxic to crop plants. All these contributing factors make composting a science as much as an art. The quality of the compost depends on how the composting process has been managed. Different degrees of maturity of compost fulfil different purposes in the soil. For example, applying mature compost leads to better soil structure and disease suppression.

Various guides to assess the quality of compost have been developed; an inexpensive and practical method is provided in the Composter's Manual by E. Pfeiffer.

Several methods of compost making (worm, Indora, Luebke or CMC, sheet, biodynamic etc.) are being researched. A further area of research examines the effects of adding minerals such as rock dust, lime, clay, rock phosphate to the compost heap rather than directly on the land. Various inoculants (starters), including the biodynamic compost preparations are also being researched.

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[1] biomass:all organic matter including living organisms like the bacteria and fungi

*Peter Bacchus has had long experience of biodynamic farming. Brought up on a biodynamic dairy farm, and served apprenticeships on other dairy farms having studied and worked on bio-dynamic farms and in a nutritional research laboratory in Switzerland, working with some of the most prominent biodynamic farming consultants and learning the sensitive chrystallisation and climbing chromatography research methods. He has worked as a medicinal herb grower for Weleda NZ and developed a large-scale composting business. He converted a commercial glass house to the biodynamic method, which included successful control of white fly and fungal problems that occur in a glasshouse situation. He has been involved with a large scale possum control trial using biodynamic methods. He is now working as consultant and laboratory researcher for Garuda Consultants and Garuda Homeopathics. He was a Councillor for the BioDynamic Farming and Gardening Association from 1963 to 1985, was re-elected in 2000, and is currently the Chairman of the Association.*

# APPENDIX 4: BOOKS ON BIODYNAMIC FARMING

A vast quantity of useful practical information on organic and biodynamic farming practices can be found in books and magazines over the last century. Much of this literature is now out of print and hard to obtain, but the Bio-Dynamic Association and the Soil and Health Association hold valuable collections. Several books on biodynamic farming and growing are listed in the booklist at the end of this appendix.

Useful books on practical farming include *Bio-dynamic Agriculture* by Koepf, Petterson and Schaumann and books by Ehrenfried Pfeiffer such as *Soil Fertility and Renewal*. New Zealand books include *Biodynamics* and *Biodynamic Perspectives* by the Bio-Dynamic Association and "Grasp the Nettle" by Peter Proctor. *Agriculture of Tomorrow* by E and L Kolisko provides interesting accounts of early research into the biodynamic preparations and other aspects of biodynamics. This and one of Pfeiffer's books are reviewed below, by Peter Bacchus,

## A Practical Guide to the Biodynamic Preparations — by Ehrenfried Pfeiffer

This small book gives a good practical overview of how to construct a compost or a manure heap and how to apply the compost preparations to it. A chapter is given to the environmental consideration of moisture. The balance of air to moisture is vital to a successful process of decomposition. In New Zealand the lack of water in summer is also a challenge. Pfeiffer recommended covering heaps with soil or clay to reduce losses of nitrogen.

A chapter discusses the biodynamic field sprays made from cow manure in the shell of a cow's horn (buried during the winter) and very finely ground quartz inserted in a cow's horn (buried during the summer months). This book does not take into account the modern mechanical aids that we now have but the principles remain the same.

Other chapters deal with the principles of the biodynamic method in orchards, and farm conversion to the biodynamic method. The final chapter addresses the issues of monoculture and its effects on the environment in comparison with the fully mixed environment with, for example, trees, woodlands, cropping and pasture diversity, whether animals should have access to eat or totally destroy any shrub they can eat, or whether they have enough shade or shelter during extreme weather conditions (hot, cold, wet, windy).

Pfeiffer, a practicing biochemist, had strong connections with the medical profession. Most of the time he was a practical farmer, which allowed him to speak with authority. He wrote many books, always sensible and practical. Any book by this author is good value for those interested in the organic approach and the practical application of the biodynamic method.

Pfeiffer became particularly noted for his compost starter. Further work on these starters in the US (Josephine Porter Institute) and Europe (Luebke or CMC composting) led to commercially developed products. Dr Pfeiffer later gave a comprehensive series of lectures on nutrition that are recorded on tapes distributed by Acres USA.

## Agriculture of Tomorrow — by Eugene and Lilly Kolisko

First published 1938, currently out of print.

This book describes the research work of the Koliskos, inspired by Dr Rudolf Steiner in 1919, nd begun in 1920. In an attempt to provide a scientific basis for certain biodynamic methods they research indications from Steiner. They took the first steps on the developmental road to a “living science”. As such this book reveals a less ‘material world’ operating behind the scenes and attempts to quantify it. Different environmental aspects and various homeoepathic dilutions were researched to understand their influence on plant growth and development.

For example, they studied the metals that relate to the sun, moon and the visible planets, Mercury, Venus, Mars, Jupiter and Saturn. Tin, one of the metals related Jupiter, was studied in great detail using growth studies on sunflowers to show the effects of the different potencies of tin as the 60th potency, with some remarkable results. A biodynamic preparation made from the plant Equisetum avense, horse tail or mares tail is also examined. This was recommended as a remedy for the effects of excessive rain, or moon force on plants. Equisetum has a high proportion of silicic acid and grows as a weed in many parts of northern Europe.

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# APPENDIX 5: ASIAN CONTRIBUTION TO SUSTAINABLE LAND MANAGEMENT

Some of modern Organics' earliest champions gleaned their knowledge from Asian sustainable land management systems. Two of the most prominent King[1] and Sir Albert Howard[2] owed much of their knowledge to China, Korea, Japan and India.

The oldest known agricultural text[3] is from China. Written in the 1st Century BC, it clearly outlines the breadth and depth of intensive production sustainable systems covering arable, vegetable and animals.

Fascination with the sustainable polycultural systems of Asia continued well into the 20th century. Examples include polycultural and agriculture dike pond systems[4] and studies of whole village interactions that combine economic, social and environmental sustainability.

The most recent work relating to sustainability and models of Sustainable Land Management Systems comes from an Australian study[5]. Here studies conclude that the:

> extensive evidence is already present regarding the failure of industrial monoculture approaches to provide for ecological sustainable land use…Since the ecological and physiological processes and theories generally arise from the study of natural ecosystems, polyculture offers an integrating bridge between natural and human systems, conceptually and on the ground. As well, the field offers an effective bridge between ecologists, agronomists and resource managers.

Full and extensive literature reviews and co-research is required to learn from and experience the Asian Pacific models of land use sustainability. As the Australian study concludes, one problem facing the actuality of sustainability in the Pacific region, is the need to acknowledge that our current systems, based on European models, are not sustainable. To move from the current model will require extensive cultural shifts but there will be equally extensive information gains.

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# GLOSSARY OF TERMS

| | |
|---|---|
| Agroecosystem | A domesticated or harvested ecosystem. |
| Biodynamic (farming and gardening) | An organic farming system introduced by Dr Rudolf Steiner. The farm is seen as an ecosystem within a wider system including the universe, but also an entity as distinct in its own right as one human being is from another. Biodynamic farming is also characterised by use of biodynamic preparations and astronomical rhythms. |
| Biodynamic preparations | Substances prepared from animal and plant material and used to level of extremes of the growing environment, activate soil biota, for compost making and for plant activity. The principle effects being normalizing, compensating and stimulating. |
| Biodiversity | The total taxonomic, functional and genetic variety of life forms supported by an ecosystem. |
| Biomass | Total mass of microorganisms and roots alive in a given volume or mass of soil. |
| Biosphere | Zone incorporating all forms of life on earth: all the earth's ecosystems functioning together on a global scale. |
| Bulk density | Mass of dry soil per unit soil volume (combined volume of soil solids and pore space). |
| Cation Exchange Capacity (CEC) | Sum of exchangeable cations a soil can adsorb at a specific pH – influences nutrient availability to plants. **or** The amount of negative charge that exists on humus and clays allowing them to adsorb cations. |
| Chromatogram | In this report, this is a picture formed when a solution of plant or animal material is absorbed by filter paper. |
| Chrystallisation | A picture-developing method for studying properties of organic solutions e.g., fruit juices, by adding to $CuCl_2$ solutions and studying the morphology of crystals formed. |
| Ecosphere | Term for all the earth's ecosystems functioning together on a global scale. |

| | |
|---|---|
| Ecosystem | A discrete unit or community of diverse organisms (includes all species of animals, plants and microorganisms) and the environment in which they live, which interact to form a stable system. |
| Emerging properties | Properties resulting from the functional interaction of components and therefore cannot be predicted from the study of components that are isolated or decoupled from the whole unit. |
| Enzymes | Proteins within or derived from a living organism that function as catalysts to promote specific biological reactions. |
| Feedback controls | Regulating mechanisms whereby the product of a metabolic pathway influences its own production by controlling the amount and/or activity of one of more enzymes involved in the pathway to reach a balance. |
| Food web | The feeding relationships of organisms within an ecosystem – a series of interconnecting food chains. |
| Goethean observation or phenomenology | A method of close observation to increase understanding of an organism, introduced by Goethe; the interrelationship of the research object and its context |
| Holistic | A study or system viewed as a whole, rather than as its component parts. |
| Homeostasis | Regulatory mechanisms, for instance, the nervous system, which keep our body temperature constant **OR** the mechanism that maintains the carbon dioxide-oxygen balance in the atmosphere. |
| Humification | A natural process whereby organic residues are transformed and converted to stable humic substances through biochemical and chemical processes. |
| Humus | The stable, high molecular weight and colloidal fraction of soil organic matter derived from decomposed plant and animal matter in the soil. |
| Immobilisation | Conversion of a plant nutrient from its inorganic to organic form by microbes or plants. |
| Infiltration rate | Rate of water entry into the surface layers of soils. |

| | |
|---|---|
| Landscape | Design of the environment. |
| Mineralisation | Conversion of a potential plant nutrient from its organic form to inorganic plant-available form as a result of soil microbial activity. |
| Mulch | Any material such as straw or leaves that is spread on the soil surface to protect the soil and plant roots from the effects of raindrops, soil crusting, freezing or water loss by evaporation. |
| Mutualistic | Behaviour working together or cooperatively. |
| Nutrient cycling | Flow of nutrients through agro-ecosystems. |
| Nutrient sinks or pools | Temporarily stored nutrients. |
| Paradigm (scientific) | A pattern of thinking that matches accepted theories and scientific practices of the day. |
| Participatory | The specific farm is treated as an experimental research station, with flexible, two-way information flow both between farmer-researcher and between farmer-farmer minimises researcher control and maximises farmer intervention in research design. |
| Phenomenology or Goethean science | A method of close observation to increase understanding of an organism, introduced by Goethe. |
| Polycultures | Growing a wide variety of crops e.g., crop rotation, inter cropping, mixed cropping, etc. |
| Rhizosphere | Zone of soil of intense microbiological activity, immediately adjacent to the plant roots, and which receives plant root exudates. |
| r-selection | The environment favors species with high reproductive potential. |
| K-selection | The environment favors species with lower growth potential but greater capabilities for utilizing scarce resources. |
| Soil biota | All living components of the biological community in soils |
| Soil organic matter or SOM | Organic fraction of the soil, usually excluding undecayed plant and animal residues |

| | |
|---|---|
| System | A discrete operational entity that consists of a number of interacting parts, within recognized boundaries |
| Transcending functions | What happens at one level affects what happens at another level |
| Understorey | Herbage growing under fruit trees in an orchard |

# ACRONYMS

| | |
|---|---|
| FAO | Food and Agriculture Organisation of the United Nations |
| FiBL | Research Institute of Organic Agriculture, Switzerland |
| HYDRA | Henry Doubleday Research Association, UK |
| IFOAM | The International Federation of Organic Agriculture Movements: the worldwide umbrella organisation of the organic agriculture movement, with about 500 member organisations and institutions in some 95 countries worldwide. One major aim is "to make an international guarantee of organic quality a reality" – the IFOAM Accreditation Programme ensures equivalency of certification programmes worldwide |
| IFP | Integrated fruit production – system adopted by many New Zealand apple growers, which combines more benign and biological methods with conventional methods of pest management |
| LBI | Louis Bolk Institue – organic research institute in The Netherlands |
| UNCED | United Nations Conference on Environment and Development |