

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 mycorrhizal (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

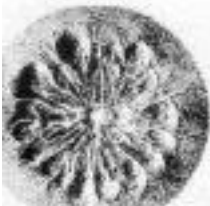
P 89 – under Frequency of applications

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 136

The “drop/pictures” referred to are:



Sketch A
Mountain stream water



Sketch B
The same stream polluted

Chapter 10

Soil and Health part by Brendan Hoare not by P Bacchus

Also in Chapter 10 some organisation contact names have been updated.

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, total weight of microbial carbon (C)
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 contain 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% (Menner *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.

References

- Aislabie, J, Smith, JJ, Fraser, R, McLeod, M. (2001) Leaching of bacterial indicators of faecal contamination through four New Zealand soils. *Australian Journal of Soil Research* 39 (6): 1397-1406
- Albiach, R, Canet, R, Pomares, F, Ingelmo, F. (2000). Microbial biomass content and enzymatic activities after the application of organic amendments to a horticultural soil. *Bioresource Technology* 75: 43-48
- Albrecht, WA (1975) *The Albrecht Papers*. Acres USA.
- Alföldi, T. (2001) Agronomic and ecological performance of organic and conventional farming systems. In: Proceedings Sino-Swiss Seminar on Plant Production with sustainable Agriculture - Research and Applications 28 May to 1 June, 2001, Zhuhai China, 92-95.
- Andrews, PK, Glover, JD, Reganold, JP. (2001) Horticultural performance, soil quality, and orchard profitability of integrated, organic, and conventional apple production systems. *Bulletin OILB/SROP* Avilla, J, Polesny, F (Eds.) 24:5 393-400 Proceedings of the IOBC/WPRS Fifth International Conference on Integrated Fruit Protection, Lleida, Spain, 22-26 October, 2000.
- Baars, T. (2001) Effects of animal manure on the growth dynamic of grass/clover on sandy soils European Grassland Federation, Witzenhausen, Germany, July 2001. In: Isselstein J, Spatz G, Hofmann M. (Eds.) *Organic Grassland Farming*, p. 291 – 294
- Bagyaraj, DJ. (1984). Biological interactions with VA Mycorrhizal fungi. In: Powell C.L., Bagyaraj D.J. (Eds) *VA Mycorrhiza* CRC Press, Boca Raton.
- Boer, I J M. de (2003) Environmental impact assessment of conventional and organic milk production. *Livestock Production Science* 80 (1/2): 69-77
- Bolan, NS. (1991) A critical review on the role of mycorrhizal fungi in the uptake of phosphorus by plants. *Plant and Soil* 134: 189-207.
- Burgt, G.J van der, Baars, T. (2001) Manure effects on soil fertility and earthworm populations earthworm populations in organic grass/clover on sandy soils . European Grassland Federation, Witzenhausen, Germany, July 2001. In: Isselstein J, Spatz G and Hofmann M. (Eds) *Organic Grassland Farming*, 281 – 283
- Carpenter-Boggs, L, Kennedy, AC, Reganold, JP. (2000). Organic and biodynamic management: Effects on soil biology. *Soil Science Society of America Journal*. 64(5), 1651-1659

Chen, J, Ferris, H. (1999). The effects of nematode grazing on nitrogen mineralization during fungal decomposition of organic matter. *Soil Biology & Biochemistry* 31 (9): 1265-1279

Clark, RB, Zeto, SK. (2000). Mineral acquisition by arbuscular mycorrhizal plants *Journal of Plant Nutrition* 23(7): 867-902

Cooperband, L (2002). The Art and Science of Composting: A resource for farmers and compost producers University of Wisconsin-Madison Center for Integrated Agricultural Systems www.wisc.edu/cias/pubs/artofcompost.pdf

Fairweather, JR, Campbell, HR (2001) Research on the consequences of converting to organic production : a review of international literature and outline of a research design for New Zealand. Agribusiness and Economics Research Unit, Lincoln University

Finlayson, JD, Betteridge, K, MacKay, A, Thorrold, B, Singleton, P, Costall, DA. (2002) A simulation model of the effects of cattle treading on pasture production on North Island, New Zealand, hill land. *New Zealand Journal of Agricultural Research* 45 (4): 255-272

Fliessbach, A, Maeder, M. (2000) Microbial biomass and size-density fractions differ between soils of organic and conventional agricultural systems. *Soil Biology and Biochemistry* 32: 757-768

Frund, HC, Gromes, R. (2002). Biological activity of soils in apple orchards differing in fungicide application and copper burden. *Erwerbsobstbau Bodenbiologische Aktivitat in Apfelkulturen mit unterschiedlicher Fungizidbehandlung und Kupferbelastung.* 44:5 129-133

Goh, KM., GE. Bruce, *et al.* (1999). Sensitive indicators of soil organic matter sustainability in orchard floors of organic, conventional and integrated apple orchards in New Zealand. *Biological Agriculture & Horticulture* 17(3): 197-205.

Gruber, L, Steinwender, R, Guggenberger, T, Plakolm, G. (2001) Comparison of organic and conventional farming on a grassland farm. 3rd Communication: nutrient balances on supply/withdrawal basis and import/export basis. *Bodenkultur*, 52: 2, 183-195:

Gunapala, N, Scow, KM. (1998) Dynamics of soil microbial biomass and activity in conventional and organic farming systems. *Soil Biology and Biochemistry*, 30:6 805-816

Hatch, D, Shepherd, M, Hatley, D. (2002) Understanding soil nitrogen supply: organic matter quality and quantity In: Powell, J (Ed) UK Organic Research 2002: Proceedings of the COR Conference, 26-28th March 2002, Aberystwyth

Heeres, E J, Bokhorst, Koopmans C (2001) Compost and manure: a source of value. 11th Nitrogen Workshop 9-12 September 2001 Reims, France p.101-102

Research update August 2003

HORT Research (2003) www.hortresearch.co.nz

Ingham, ER. (1998) Protozoa and Nematodes In: Sylvia, D.M., Fuhrmann. JJ., Hartel, PG, Zuberer, DA. (Eds) *Principles and Applications of Soil Microbiology*. Prentice Hall, New Jersey

Ingham, ER. (2002) Workshops given in New Zealand March, 2002.

Kemp, PD, Mackay, AD, Matheson, LA, Timmins, ME. (2001). The forage value of poplars and willows. *Proceedings of the New Zealand Grassland Association* 63: 115-119

Kirkman, JH, Basker, A, Surapaneni, A, MacGregor, AN. (1994). Potassium in the soils of New Zealand - a review. *New Zealand Journal of Agricultural Research* 37 (2): 207-227

Klein, CAM de, Sherlock, RR, Ledgard, SF, Barton, L, Kelliher, FM, Walcroft, AS, Rys, G. (2002). Nitrous oxide emissions from New Zealand agriculture: research to refine the national inventory. In: Ham, J, Baede, APM, Guicherit, R, Williams-Jacobse, JGFM..(Eds) *Non-CO2 greenhouse gases: scientific understanding, control options and policy aspects*. *Proceedings of the Third International Symposium, Maastricht, Netherlands, 21-23 January 2002*

Koopmans, C, Goldstein, W. (1999) *Soil Organic Matter Budgeting in Sustainable Farming* Michael Fields Agricultural Institute.

Koopmans, CJE, Heeres, J, Bokhorst (2001) Nitrogen mineralization in organic farming systems: validation of the NDICEA model In: Recous, S. et. al. (eds.) *11th Nitrogen workshop*. 9-12 September 2001, Reims, p. 403-404. INRA, Reims, France

Li, XL, Marschner, H, George, E. (1991) Acquisition of phosphorus and copper by VA-mycorrhizal hyphae and root-to-shoot transport in white clover. *Plant and Soil* 136 (1): 49-57

Loes, A. (2000). Phosphorus and potassium concentrations in soil after long-term organic farming. *IFOAM 2000: the world grows organic*. *Proceedings 13th International IFOAM Scientific Conference, Basel, Switzerland, 28 to 31 August,*

Mackay, AD, Harrison, T, Moss, RA, Fraser, T.J, Rhodes, AP, Cadwallader, D, Fisher, M, Webby, R. (2000). *Moving towards low-chemical and caring farming systems*. Meat NZ. Report 99PR/3.

Mäder, P, Fliessbach, A, Dubois, D, Gunst, L, Fried, P, Niggli, U. (2002) Soil Fertility and Biodiversity in Organic Farming *Science* v.296, n.5573

Mata, M, Garrido, M, Longhurst, P, Seaton, R. (2002) A method for soil health assessment in the conversion to organic farming In: Powell, J (Ed.) UK Organic Research 2002: Proceedings of the COR Conference, 26-28th March 2002, Aberystwyth

Menneer, J, Ledgard, S, McLay, C, Silvester, W. (2001) What impact does dairy cow pugging have on clover N₂ fixation and long-term farm production? Proceedings of the New Zealand Grassland Association 63: 63-67

Merrington, G, Rogers, SL, Zwieten, L van. (2002) The potential impact of long-term copper fungicide usage on soil microbial biomass and microbial activity in an avocado orchard. *Australian Journal of Soil Research* 40:5 749-759

Mullen, MD. (1998) Transformation of other elements In: Sylvia, DM, Fuhrmann, JJ, Hartel, PG, Zuberer, DA. (Eds.) *Principles and Applications of Soil Microbiology*. Prentice Hall, New Jersey

Nie, ZN, Mackay, AD, Valentine, I, Barker, DJ, Hodgson, J. (1997). Influence of pastoral fallow on plant root growth and soil physical and chemical characteristics in a hill pasture. *Plant and Soil* 197: 201-208.

Oberson A. *et al.* (2000) Can increased soil microbial activity help to sustain phosphorus availability? In: Alföldi T *et al.* (Eds) Proceedings 13th International IFOAM Scientific Conference vdf Hochschulverlag Zurich

Owens, C, Watson, K. (2002) Nutrient budgeting for trace elements: Examples from Scottish organic farms In: Powell, J (Ed) UK Organic Research 2002: Proceedings of the COR Conference, 26-28th March 2002, Aberystwyth

Pamidi, J, Goh, KM, McLaren, RG. (2001). Comparison of three different methods of determining soil sulphur mineralization in relation to plant sulphur availability in soils. *Biology and Fertility of Soils* 34: 131-139

Pinxterhuis, I, Wagenaar, JP, Plomp, M. (2002). Botanical composition and forage quality of grasslands in organic dairy farming. In: Durand, JL, Emile, JC, Huyghe, C, Lemaire, G. (Eds.) Multi-function grasslands: quality forages, animal products and landscapes. Proceedings of the 19th General Meeting of the European Grassland Federation, La Rochelle, France: 1064-1065

Raupp, J, Oltmanns, M. (2002) Fractions of particulate organic matter in soils depending upon farmyard manure and mineral fertilization. Proc. 14th IFOAM Organic World Congress, 21-24 August 2002, Victoria, Canada; p. 25

Raupp, J. (2002) Monitoring nutrient turnover during composting has to be based on a constant reference parameter. Is total ash content really a good choice? Proc. 14th IFOAM Organic World Congress, 21-24 August 2002, Victoria, Canada; p. 66

Research update August 2003

Reganold, JP, Palmer, AS, Lockhart JC, Macgregor, AN. (1993) Soil quality and financial performance of biodynamic and conventional farms in New Zealand. *Science* 260: 344-349.

Sarapatka, B. (2000). Impact of different farming systems and soil properties on soil enzyme activities In Proceedings 13th International IFOAM Scientific Conference Alfoldi T. *et al.* (Eds) vdf Hochschulverlag AG on der ETH. Zurich.

Scheller, E. (2000). Importance of protein and amino acid metabolism in soil for plant nutrition and soil fertility. IFOAM: the world grows organic. Proceedings 13th International IFOAM Scientific Conference, Basel, Switzerland, 28 to 31 August, 2000.

Schjonning, P, Elmholt, S, Munkholm, LJ, Deboz, K. (2002) Soil quality aspects of humid sandy loams as influenced by organic and conventional long-term management. *Agriculture, Ecosystems & Environment* 88:3 195-214

Scholz, KP, Helm, HU. (2000). N-nutrition of apple, part 1: principles of N-supply. *Erwerbsobstbau Die Stickstoffernahrung beim Apfel*, 1. Teil: Grundlagen der N-Versorgung. 42:6 192-200

Schonbeck M. (2000). Soil Nutrient Balancing in Sustainable Vegetable Production A Final Report submitted to the Organic Farming Research Foundation, December 2000 *Virginia Association for Biological Farming*.> <http://www.vabf.f2s.com/soilre1.php>

Scow, D, Walters, C. (1995) *Mainline Farming for Century 21 USA*

Singleton, PL, McLay, CDA, Barkle, GF. (2001). Nitrogen Leaching from soil lysimeters irrigated shed effluent and having managed drainage. *Australian Journal of Soil Research* 39 (2): 385-396

Soil and Health Association and Biodynamic Farming and Gardening Association of New Zealand. (2003) Organic Avocado, Organic Citrus, Organic Summerfruit and Organic Pastoral Resource Guides

Sparling, G, Vojvodic-Vukovic, M, Schipper, LA. (1998). Hot-water-soluble C as a simple measure of labile soil organic matter: the relationship with microbial biomass C. *Soil Biology & Biochemistry* 30 (10/11): 1469-1472

Sullivan, P. (2001) Sustainable Soil Management Soil Systems Guide. Appropriate Technology Transfer for Rural Areas (ATTRA) Fayetteville, AR 72702
<http://attra.ncat.org/attra-pub/PDF/soilmgt.pdf>

Surapaneni, A, Palmer, AS, Tillman, RW, Kirkman, JH, Gregg, PEH. (2002) The mineralogy and potassium supplying power of some loessial and related soils of New Zealand. *Geoderma* 110 (3/4): 191-204

Research update August 2003

Suzuki, H. *et al.* (2001). Transport of trace elements through the hyphae of an arbuscular mycorrhizal fungus into Marigold, determined by the multitracer technique. *Soil Science Plant Nutrition*, 47 (1): 131-137.

Tagmann, HU, Oberson, A, Oehl, F, Frossard, E, Dubois, D, Mader, P. (2001). DOC-trial: phosphorus budget and availability over 21 years. *Agrarforschung.*, 8: 8, 318-323:

Tarafdar, JC, Rao, AV. (2002) Possible Role of Arbuscular Mycorrhizal Fungi in Development of Soil Structure In: Sharma, AK, Johri, BN. (eds.) *Arbuscular Mycorrhizae Interactions in Plants, Rhizosphere and Soils* Enfield, NH : Science Publishers

Tremblay, N, Scharpf, H, Weier, U, Laurence, H, Owen, J. (2001) Nitrogen Management in Field Vegetables - A guide to efficient fertilisation
http://res2.agr.ca/stjean/publication/bulletin/nitrogen8-azote8_e.htm

Tutua, SS, Goh, KM, Daly, MJ, (2002). Decomposition and nitrogen release of understorey plant residues in biological and integrated apple orchards under field conditions in New Zealand. *Biology and Fertility of Soils* 35 (4): 277-287

Waipara, NW, Hawkins, SK. (2000). The effect of dairy-shed effluent irrigation on the occurrence of plant pathogenic *Pythium* species in pasture. In: Zydenbos, SM. (Ed.) *New Zealand Plant Protection Volume 53, 2000. Proceedings of a conference, Commodore Hotel, Christchurch, New Zealand, 8-10 August 2000* 436-440

Watson, CA, Bengtsson, H, Ebbesvik, M, Loes, AK, Myrbeck, A, Salomon, E, Schroder, J, Stockdale, EA. (2002). A review of farm-scale nutrient budgets for organic farms as a tool for management of soil fertility. *Soil Use and Management* 18 supplement 264-273

Woodward, S (2003). Is it all just hot air? DEXCEL www.dexcel.co.nz/research_hs.html

Zaman, M, Cameron, KC, Di, HJ, Inubushi, K. (2002). Changes in mineral N, microbial biomass and enzyme activities in different soil depths after surface applications of dairy shed effluent and chemical fertilizer. *Nutrient Cycling in Agroecosystems* 63, 2/3: 275-290.

Zimmer, G F, (2000) *The biological farmer: a complete guide to the sustainable & profitable biological system of farming* Austin, Tex. : Acres U.S.A.