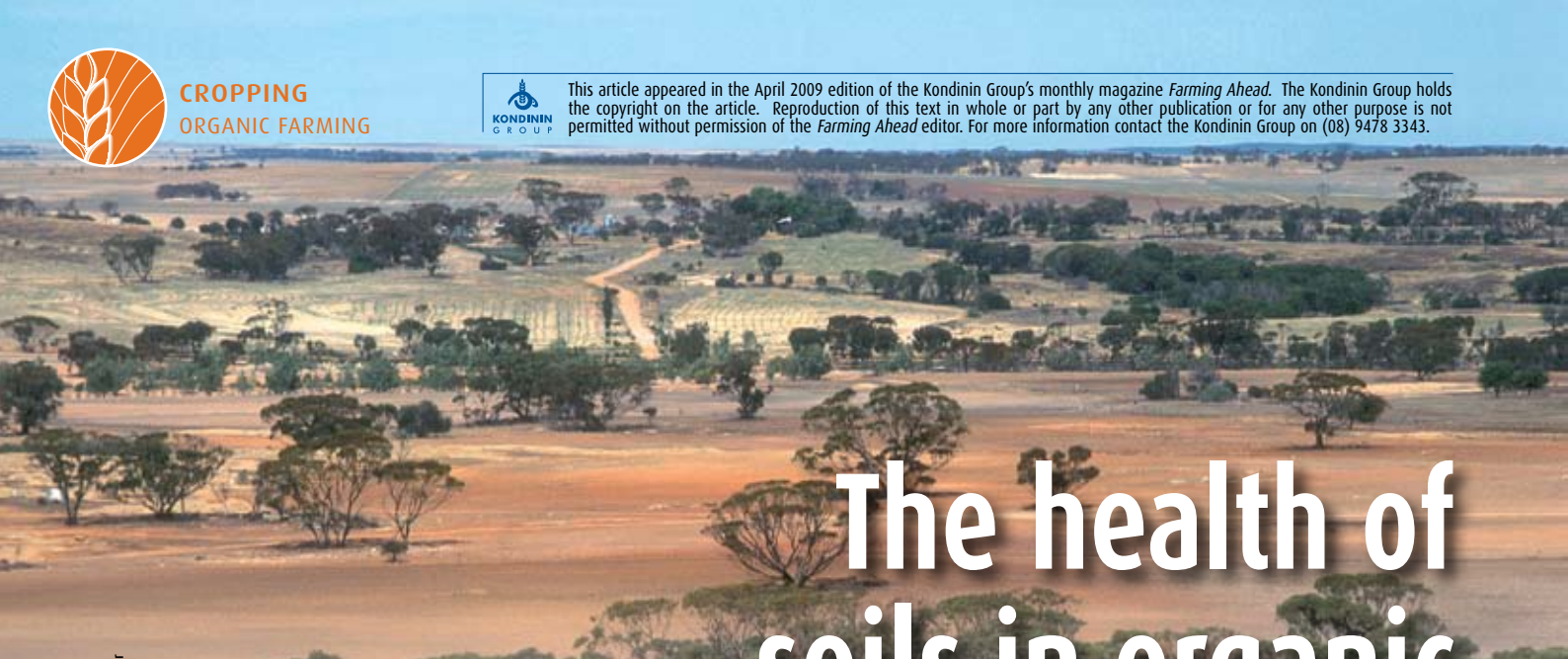
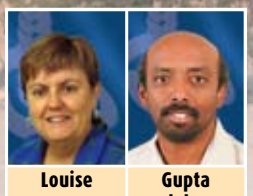


Photo: Willem van Aken, CSIRO Land & Water

The health of soils in organic farming systems



Louise Lawerence **Gupta Vadakattu**
For CSIRO ENTOMOLOGY

More popular: *Agricultural systems that follow organic farming principles have spread from their early base in intensive horticulture to broadacre, rain-fed cropping systems.*

CSIRO scientists have recently completed one of the first detailed studies of the diversity and activity of soil microbes in broadacre organic farming systems in southern Australia. The results of this study will help in the development of best management practices for organic farmers.

At a glance

- Organic farming is seen by its adherents as an alternative to what they consider to be input-laden and intensive modern agriculture.
- Organic farms differ from conventional farms in not using inorganic fertilisers and pesticides and the use of cultivation instead of herbicides for weed control.
- Researchers analysed the biological status of organic soils and linked this information to functions necessary for plant growth and performance, to measure the efficiency of the organic soils.

Organic farmers and the steadily-expanding organic farming movement will benefit from the findings of a CSIRO study into the diversity and activity of soil microbes in broadacre organic cropping systems in southern Australia.

The study will provide the industry with a basis on which to develop best practice management strategies.

Long history

Australia has a long history of organic farming, although until recently it has generally been regarded as a niche market in the broader agricultural picture. Now, agricultural systems that follow organic farming principles have spread from intensive horticulture, where they were initially focused, to broadacre, rain-fed cropping systems.

CSIRO scientists have recently completed one of the first detailed assessments of soil biological capacity under broadacre organic farming systems in southern Australia's rain-fed agricultural region. The aim of the study was to examine the status of key functional groups of soil microbiota and their associated functions that are essential to plant health.

Alternative approach

Organic farming is seen by its adherents as an alternative to what they consider to be input-laden and intensive modern agriculture. They believe these inputs are not necessary for environmentally friendly, sustainable and economically viable farming.

Organic farms differ from conventional farms in not using inorganic fertilisers and pesticides and the use of cultivation instead of herbicides for weed control. Organic farmers believe the nutrient requirements for their soils will be met naturally through processes such as nitrogen fixation by legumes and improvements to soil biological fertility and reserves of nutrients (for example, phosphorus and potassium) built up from the use of fertilisers in the past.

Added organic matter

It is considered that organic systems generally have large amounts of organic matter added, leading to an increase in soil biodiversity with a consequent increase in biological activity. This might be true where water, through either rainfall or irrigation, is not a constraint. But in the broadacre rain-fed cropping systems of southern Australia, additions of organic matter such as manures are not always possible. The farms are often very large and organic materials are not always available in bulk.

Availability of carbon

Recent research on southern Australian farms points to the availability of carbon as one of the major factors limiting the biological processes essential for healthy ecosystem functions in soil. These functions are essential for plant health.

On broadacre organic farms, crop residues are the only materials available for

nutrient recycling, perhaps boosted by limited inputs of permitted fertilisers. In southern Australia, this is an important issue for organic farmers because, in their soils, nutrient cycling and other biological functions such as disease suppression depend on the availability of biologically available carbon. This is because most microbes depend on carbon as a source of energy.

Other factors impacting on the rate of carbon turnover include soil type, environmental factors and management issues such as tillage and rotation. These factors can affect the diversity of essential groups of biota as well as soil habitat characteristics.

Soil health assumptions

Although organic farmers assume soil biological activity is enhanced in organic systems, general trends in organic production point to lower yields. This could be as a result of lower levels of carbon inputs where crop residues are the only source of carbon. Until recently, there was little evidence on whether assumptions on soil health on organic broadacre farms were true.

Working in consultation with various organic farming industry bodies, the scientists collected soil samples from 13 farm paddocks (six organic, six no-till conventional cropping and one conventional pasture-crop system) in South Australia, Victoria and New South Wales. Average annual rainfall at the sites varied from less than 300 millimetres (SA) to more than 500 mm (NSW).

Soil samples analysed

The organic farms all had a reliable history of at least five years under organic growing conditions. Samples were analysed for a variety of soil microbial diversity, population levels and activities of selective functional groups. Results from organic soils were compared with those for soils from nearby conventional farms. Analysis was done in soils collected before sowing and when the crops were flowering.

The aim was to look at the biological status of the soil and link this to functions necessary for plant growth and performance, to measure the efficiency of the organic soils. Earlier research had shown that such biological measurements reflect the nutritional and disease potential status of the soil.

Significant differences found

The analyses showed the genetic and catabolic (ability to break down large molecules into molecules usable by plants) diversities of soil bacterial and fungal communities were significantly different between organic farming systems and neighbouring conventional farms.

One significant finding was that soil type had a significant impact on the nature and magnitude of farming system effect. Following pastures, organic farm soils at pre-sowing contained higher levels of the microbial biomass (total microbial community — MB) carbon and nitrogen, organic carbon and microbial activity compared with no-till cropping soil, with the effect varying according to soil type. But this is likely to be due to crop rotation and cultivation rather than the organic nature of the farming system.

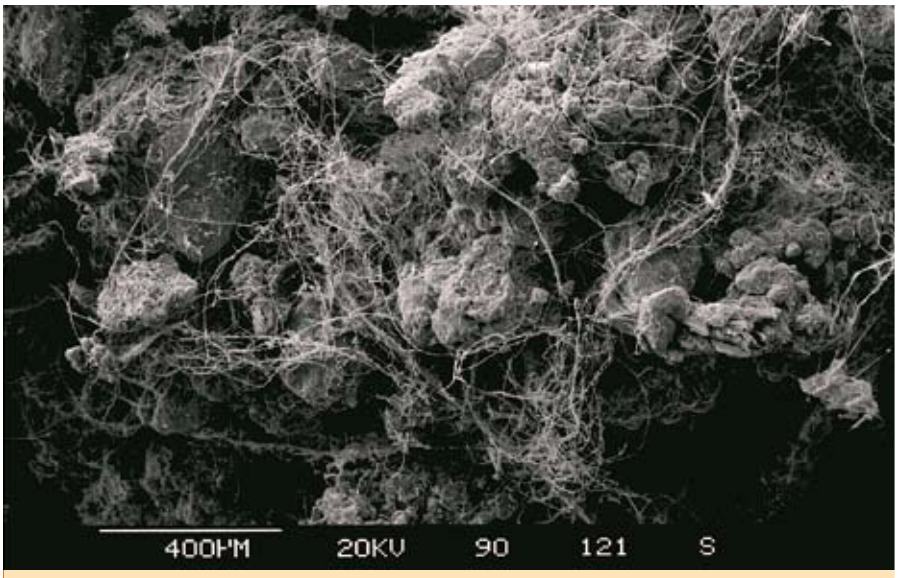


Photo: CSIRO

Fungal networks: *Threadlike fungal networks hold soil particles and micro aggregates onto the surface of crop residues as part of the formation of stable soil aggregates. Cultivation disrupts soil aggregates whereas minimum till combined with stubble retention enhances aggregate stability, stimulates microbial growth and improves soil structure.*

Mallee soil results

In the one example of neighbouring farms with similar rotations (Mallee soils), conventional pasture-crop rotation exhibited higher MB than organic farm soils. Respiratory quotient (the ratio of the carbon dioxide produced to the amount of MB) was lower in conventional farm soils than in the organic farm soils, probably because of differences in the composition of the microbial community or differences in the metabolic status of the microbes.

The availability of nutrients, cultivation and the presence of agrochemicals are some of the factors that can influence the metabolic status of soil micro-organisms.

Nitrifying micro-organisms

Populations of nitrifying micro-organisms that produce nitrogen in a form usable by plants were higher in organic farm soil at pre-sowing compared with conventional farm soils.

This was probably due to the nitrogen-rich pasture residues on organic farms, which usually had a legume component and repeated cultivations used for weed management, which incorporated plant matter into the soil.

In the Mallee, the conventional pasture-crop rotation soils contained higher nitrifying populations than the organic farm soils. Most organic systems follow pasture-crop rotations and pastures, which have a legume component and this can increase organic nitrogen inputs at sowing. But the differences did not persist in the 'in-crop' soils. Unlike the organic farm soils, biological activities in no-till farm soils were generally increased in the 'in-crop' soils.

Phosphorus reserves

There is a belief that perceived improvements to biological fertility in organic farming systems facilitate the increased use of reserves of nutrients such as phosphorus that are in the soil. But the results indicated that activity of phosphatase enzymes (enzymes involved in the release of plant available forms of phosphorus) was lower in organic farm soils.

Organic farm soils in the Mallee contained the lowest amounts of MB carbon and nitrogen and mineralisation potential, particularly in the 'in-crop' soils. Mallee soils are sandy and provide little protection for both soil organic matter (which is more exposed to being broken down) and their microbial communities.

Lower biological status

Micro-organisms have fewer protected places where they can survive during periods of harsh (dry and hot) conditions or escape predation by soil fauna. These could be the reasons for the loss of organic matter and lower biological status in these organic farm soils. There is a need to increase carbon inputs from crop residues and reduce the repeated cultivations used in weed management in order to improve the biological benefits in these soils.

Soil-borne diseases

Soil-borne diseases are an important constraint to broadacre farming in Australia. When fungi that cause plant diseases

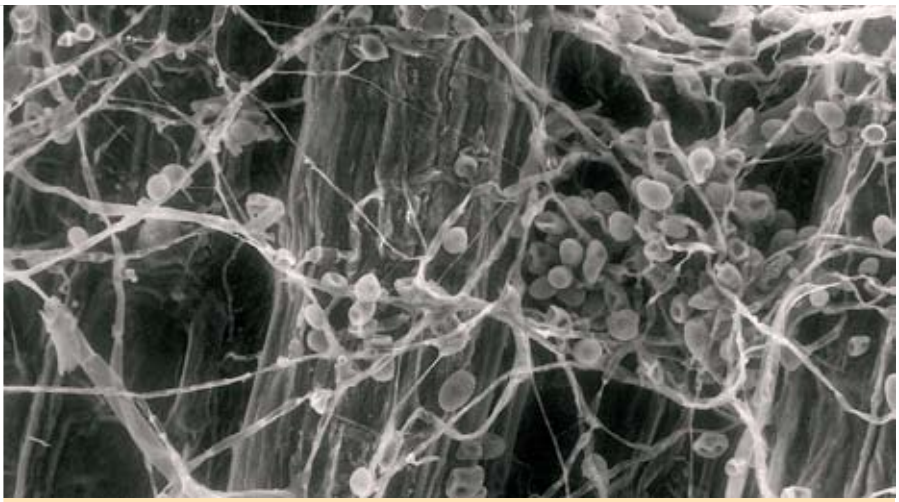


Photo: CSIRO

Crop residues: *The surface of crop residues colonised by fungi, bacteria and amoebae with shells. Decomposing plant residues are one of the key centres of microbial populations and activity in Australian soils. Organic systems with greater plant diversity could help build such micro-sites of greater biological activity.*

(pathogenic fungi) were examined, soils from organic farms contained lower levels of *Rhizoctonia solani* AG8 compared with no-till soils but other fungi such as *Pythium* and *Fusarium pseudograminearum* were higher in organic farm soils. Populations of beneficial or useful fungi such as *Trichoderma* were lower in organic farm soils.

The presence of higher levels of some soil-borne pathogens, combined with lower levels of beneficial fungi such as *Trichoderma* species, suggests the organic farming soils looked at in this study might not be capable of high levels of biological disease suppression (the ability of a soil to reduce disease severity even in the presence of a pathogen). These higher levels of soil-borne pathogens in organic farming soils suggest regular monitoring should be undertaken as part of the decision making on which rotation crops to use.

Wider scale analysis needed

It is important to remember that soil type and environmental variation had a considerable effect on the soil biological status in organic farming systems. Some important differences in specific soil biological properties do exist between organic and conventional farming systems; but it is difficult to arrive at generalised universal conclusions because of these effects. A wider scale (regional and soil type based) analysis of organic farming systems for their soil biological status is needed to generate conclusions with broader applications and with more relevance to different regions.

Results obtained in this study clearly show an enhanced soil microbial community and biological processes, relative to conventional systems, might not be a definitive feature of all broadacre organic systems.

Although organic farming approaches sometimes supported higher soil biological activity, it was not on its own a determining factor, other variables such as soil type were still important predictors. FA

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CSIRO research

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