10.1071_ISSN0311-4546EC106p12

dirty deeds

Jean Devonshire, CSIRO Entomology

A pest and its natural enemy.
Above: Kelly's citrus thrips, a major pest of citrus in the Riverland of South Australia.
Below: A predatory mite of the genus *Hypoaspis*, one of several generalist mite predators thought to be natural enemies of the larvae of Kelly's citrus thrips.

Subterranean alliances are being forged in citrus orchards of the Riverland.
Steve Davidson pays homage to the soil community.

At best, most of us think of soil as a mysterious source of sustenance for plants. At worst, we dismiss it at as barren dirt. But those that study the stuff know that most soil absolutely teems with life.

The array of life forms underfoot – the various mites, springtails, worms, fungi and bacteria, to name a few – rivals that of a coral reef. Many also occur in great numbers. Indeed it can be hard to draw a line between the soil itself and the mostly tiny animals and microbes live in it.

One square metre of grassland or woodland soil can contain hundreds of thousands of soil microarthropods (mainly springtails and mites), perhaps a million or more nematode worms, and probably many billions of bacteria.

Some kinds of soil organisms chew or suck on plant roots or consume microbes, some are decomposers that derive sustenance from organic debris, and others are fearsome parasites or predators. Some soil animals spend their entire lives in the darkness of soil, while others spend only a part of their life cycle underground.

We are only just beginning to appreciate and understand the functional links between these subterranean systems and above-ground ones, and the benefits they offer.

Learning partnerships

Mick Punturiero is a citrus grower in the Riverland region surrounding Renmark in the South Australian mallee country. He produces quality limes, oranges and lemons and mandarins for national and international markets and also supplies fruit for juicing. Perhaps unexpectedly, he's also a keen advocate of soil biodiversity.

Punturiero is one of eight citrus growers in the region that were the driving force behind a research project being conducted by soil ecologist Dr Matt Colloff and his colleagues at CSIRO Entomology.

The scientists have been working with the commercial growers and a local community-based conservation program known as Bookmark Biosphere Reserve, one of 357 international 'biospheres' created by UNESCO. The aim of the program is to reduce on-farm costs by better management of soil biological diversity.

The mallee, a landscape of multi-stemmed eucalypts, was once described as 'hard land to love'. But Punturiero's well-kept orchards reflect the pride that growers in the region take in their intensive and efficient enterprises.

'We wanted to find ways to manage the land that would mean our industry will have a future, so we approached the CSIRO,' Punturiero says.

The outcome was a research project funded by the National Heritage Trust – a 'learning partnership' between farmers, scientists and community conservationists – that aims to use soil biodiversity to

Matthew Colloff, CSIRO Entomology

Matthew Colloff, CSIRO Entomology

reduce artificial fertiliser and pesticide use, and achieve ecologically sustainable development. 'If we can learn to make use of the free services provided by biological biodiversity, farmers will be closer to achieving ecological and economic sustainability,' Colloff says.

These services, provided by bacteria, fungi, and larger soil animals, include decomposition and nutrient cycling, nitrogen fixation and pest control: crucial processes in any farming enterprise. An added bonus is the attraction of sustainably-produced fruit to increasingly health-conscious consumers.

But is this just wishful thinking? It would seem not. Preliminary results of the project indicate that citrus growers can gain tangible benefits.

For two years, 'on-hands-and-knees' surveys have been conducted of biological diversity and physical, chemical and hydrological soil properties under four typical citrus management systems: organic, pesticide free, conventional and 'high-tech', in which systematic monitoring is used to control mineral fertilisers and synthetic pesticides.

The researchers then measured abundance and species diversity of soil organisms, assigned them to functional groups, and constructed food webs for modelling the flow of nutrients and energy in soil.

Pesky thrips and killer mites

The results showed that organic producers tended to have the highest biodiversity in their soils, followed by the pesticide-free growers, then high-tech, then conventional.

Properties with high soil biodiversity also tended to have many kinds of pests, but none caused significant crop damage. In contrast, the properties with low soil diversity often had at least one major pest species causing serious economic damage. One of the well-known benefits of biodiversity is the stability it provides.

The worst of the troublesome pests was a little insect called Kelly's citrus thrips. It feeds on the skin of the citrus fruit, and the flowers, causing some $6 million worth of damage a year in Australia.

Unfortunately, no effective long-term control measure for thrips is available to growers and, in late 1999, the Riverland orchardists requested that the CSIRO scientists concentrate their efforts on this troublesome pest.

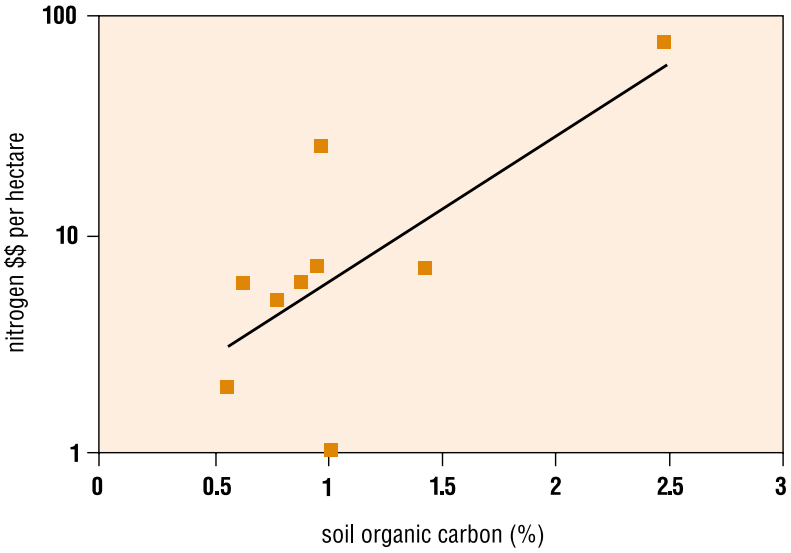
Above left: Dense ground cover of perennial grasses and herbs in a Riverland citrus orchard. The ground cover provides habitat for a series of natural enemies of citrus pests. When cut and used for mulch, the grasses reduce water loss from transpiration, thus increasing irrigation efficiency as well as providing organic matter for the soil.

Above right: Inter-row cover consisting of a few grasses and weeds and bare soil. This provides little habitat for natural enemies. Orchards with ground cover of this type are more prone to attacks by Kelly's citrus thrips.

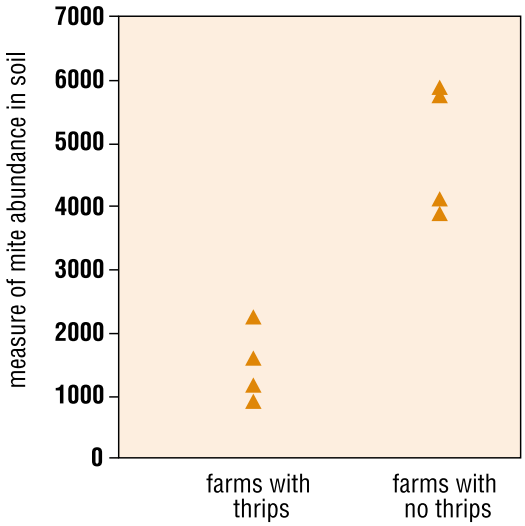
Colloff's group found that some orchards were infested by thrips while others were thrips-free. Those farms that were free of thrips tended to be those having a good ground cover, a fairly dense and diverse sward of perennial grasses and herbs, whereas those plagued by thrips typically had a ground cover of either bare soil, annual weeds or a monoculture such as lucerne.

It emerged that perennial ground cover provides superior habitat, and a supplementary pollen food source, for predatory mites that feed on the thrips larvae, which live in soil. Soil sampling revealed that properties with a thrips problem were

Valuing the nitrogen in soil animals



Soil mites control thrips



Abstract: Riverland citrus growers, CSIRO entomologists and the Bookmark Biosphere Reserve are working together to reduce on-farm costs by better managing soil biological diversity. Properties with high soil biodiversity were found to have many kinds of pests, but none causing significant crop damage. Properties with low soil diversity often had at least one major pest species. It emerged that perennial ground cover provides superior habitat, and a supplementary pollen food source, for predatory mites that feed on the larvae of Kelly's citrus thrips, a major pest in the region. A diverse ground cover also improved soil water retention, reduced evaporation and increased organic matter. This in turn improved nutrient retention and reduced nutrient run-off to the Murray River.

Keywords: soil organisms, biodiversity, citrus orchards, insect pests, pest control, predatory mites, soil organic carbon content, Kelly's citrus thrips, Riverland region, SA.

Dr Matt Colloff and his colleagues at CSIRO Entomology have sown that high soil biodiversity can mean less crop damage by insect pests.

usually those with very few soil mites, while properties with no thrips had an abundance of predatory mites, of several species, in the soil.

So growers such as Mick Punturiero now have a scientific basis for conservation control of thrips. They know that they can encourage mercenary soil mites, which occur naturally in healthy soil, by providing suitable ground cover. These findings now form the basis of an integrated pest management project for this pest at the South Australian Research and Development Institute.

Dollars down-under

A diverse ground cover has other knock-on effects of benefit to farmers. It improves soil water retention, reduces evaporation and leads to a build up of organic matter. When incorporated into soil, again due to the action of soil animals, plant material improves the condition of mallee soils, which are notoriously sandy and porous.

The researchers found that properties with a high soil organic carbon content had greater soil biodiversity. A 1% increase in organic carbon potentially means a five-fold increase in biomass of soil animals. Furthermore, organic fertilisers and manures improve nutrient retention and so reduce run-off of harmful nutrients to the Murray River.

To catch the attention of cost-conscious growers, Colloff used his empirical survey data, together with tables that show the nitrogen content of different animal groups, to calculate the dollar value of soil animals in terms of their nitrogen content.

On average, 45% of the dry weight of insects, for example, is nitrogen. When soil organisms die and decompose, they bequeath a pool of slow-release nitrogen for plants – just one part of the nutrient cycle, mediated by soil organisms.

So are soil animals worth their weight in fertiliser? The nitrogen value of soil invertebrates, averaged over the eight properties studied, turned out to be $14 per hectare, with a maximum value of $76 per hectare, on an organic property.

These numbers are conservative as they do not include fungi and bacteria, which probably have double the biomass of soil animals. And nitrogen cycling is just one aspect of soil ecosystems. Colloff says these dollar values could be greatly improved on most farms with adoption of simple management practices that encourage soil biodiversity.

Many Riverland citrus growers are certainly convinced that nurturing soil biodiversity reaps dividends. They have developed a Best Management Practice (BMP) code for sustainable citrus production that includes consideration of soil biodiversity and predator-prey interactions.