Worming their way into cotton soils

By Louise Lawrence and Geoff Baker, CSIRO Entomology

Aristotle said that earthworms are 'the intestines of the earth' and farmers have been discovering the truth of that ever since. In many agricultural systems, research has shown that soil fauna such as earthworms can make a huge difference to soil quality.

Their presence affects soil structure and fertility (for example porosity, nutrient cycling, retention of nutrients on-farm), disease and pest incidence, and plant production and quality. There is now considerable attention being paid to maintaining sustainable cotton ecosystems, including keeping cotton cropping soils healthy. Yet very little is known about the role of the complex web of soil fauna in cotton soils.

In a CRDC funded project, Geoff Baker from CSIRO Entomology has begun to clarify some aspects of the potential contribution of soil fauna to cotton production. Once the important components of the fauna and the mechanisms through which their impacts are mediated are understood, it may be possible to manipulate them to improve cotton soils and so improve plant health and raise yields.

The first soil organisms to come under the microscope were earthworms. In the past, some cotton farming practices, such as heavy pesticide use and tillage, were likely to be earthworm 'unfriendly'. Growers have now reduced their pesticide use and are using softer chemicals. They have also reduced tillage — improving the retention of organic matter.

These changes should all make conditions in cotton soils more favourable to earthworms. In reduced tillage systems, soil engineers such as earthworms can take on critical roles once performed by the plough, such as redistribution of organic matter through the soil profile.

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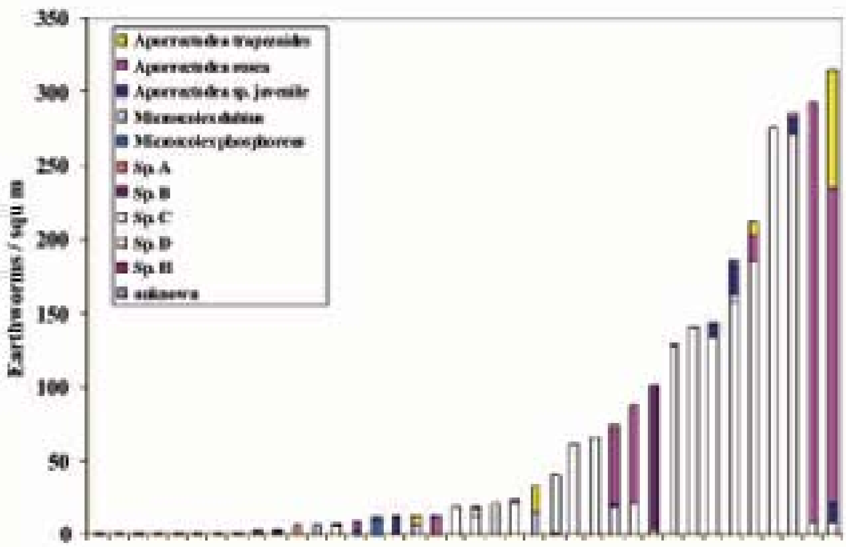
The worm diggers: Donna Jones, Paul Williams and Fiona Raynor.

FIGURE 1: Abundance of earthworms at individual transects in "cropping" soils, where at least one earthworm was found — sites are arranged in order of increasing total abundance



(Note: there were 99 sites where no earthworms were found). The named species are exotic (introduced) species. Species A-H are unidentified native earthworm species. In most samples, either exotic or native species are dominant.

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IN THE NAMOI VALLEY

The first task was to survey cotton fields to determine what earthworm species are present, how abundant they are and the major factors affecting their abundance. The field work in the early surveys concentrated on soils in and near cotton fields in the Namoi Valley.

Earthworms were collected from a mix of dryland and irrigated farms with a focus on the latter. 'Undisturbed' soils that were sampled included roadside verges, stock routes and pastures.

It was obvious from the outset that the recent long, severe drought in northern NSW was probably having a considerable impact on earthworms through prolonged low soil moisture. When soil dries out, earthworms retreat deep into the soil, making them difficult to sample.

Earthworms were found to be more common in soils where cotton had recently been grown than in less disturbed soils nearby. This was unexpected as, in other systems, tillage has been shown to reduce earthworm abundance. It is possible that the earthworms were taking advantage of the higher soil moisture in irrigated crops.

Earthworm abundance in cropping soils was most strongly correlated with particle size (especially silt percentage) and electrical conductivity, while species richness was greatest in the undisturbed soils.

Although the abundance of earthworms in the cropping soils in the Namoi Valley was low, it was comparable with those in other cropping systems in southern Australia (such as in wheat growing areas). What was unexpected was the high frequency of native earthworm species in the Namoi soils.

The biology of these native species is virtually unknown and so their role in improving soil heath is still to be uncovered. At all the sites sampled, there was rarely an even mix of native and exotic species — one or the other was usually dominant (Figure 1). In comparable surveys in cropping fields in South Australia, Victoria and Western Australia, the earthworm fauna was dominated by exotic species such as the European *Aporrectodea trapezoides* and *A. rosea*.

IN THE GLASSHOUSE

The suitability of two common 'cotton' soils (a grey clay from ACRI, near Narrabri and a red-brown earth from near Hillston) and a commercial sandy loam for earthworms was studied using two exotic species, *Aporrectodea caliginosa* and *A. longa*. These earthworms have contrasting burrowing and feeding behaviours.

A. caliginosa feeds mostly within the mineral soil layer and most of its burrows are horizontal. *A. longa* feeds mostly at the soil surface and most of its burrows are vertical. These experiments were conducted in pots over several weeks.

The earthworms survived in the ‘cotton’ soils but their growth was generally less than in the commercial sandy loam. But curiously, both earthworm species preferred the Narrabri and Hillston soils to the sandy loam when given choices.

Some commonly used pesticides (such as endosulfan) killed the earthworms when applied directly to them but had no effect on survival or growth when applied to the soil in which they were being reared. Short term flooding in Narrabri soil was tolerated well by the earthworms.

When the soils in the pots were examined, the results were very different. The Narrabri soil was riddled throughout with macropores which indicated substantial earthworm activity, while the earthworms in the Hillston soil and sandy loam were mostly in the top half. When worms were washed at the end of the experiment, the sandy loam worms were highly active, the Narrabri soil worms less so and the Hillston soil worms much less so.

The glasshouse experiments showed no convincing positive effect on cotton plant growth, at least for the young plants used. When wheat was grown in the same soils, the presence of earthworms had a positive effect. So cotton and wheat plants appear to respond differently in their early growth to the presence of earthworms (Figures 2 and 3).

This differential response between plants is not new. In CSIRO experiments in South Australia, for example, wheat and oats grew and yielded more in field cages which included *A. trapezoides* but lupins did not. In several tropical countries, field trials have shown that, while grain biomass of sorghum and maize can be greatly increased by the addition of worms, yields of cowpea and peanuts are reduced.

The implications for cotton production and quality through improved management of soil fauna such as earthworms needs to be explored further. We need to take a systems-based approach to the benefits that can accrue from managing soil fauna. Benefits may flow, for example, indirectly to cotton through impacts on other crops.

WHERE TO NOW?

This research project was a preliminary foray into the importance of one component of the soil biota — earthworms. It focused on one cotton production valley, one main soil type and only considered the short term influence of earthworms on seedling crops.

More extensive research on the most common earthworm species in cotton fields and their influence on the physical and chemical properties of soil, plant diseases and the dynamics of pest and beneficial species in cotton is needed.

It was also obvious that earthworm abundance varied greatly between farms in the Namoi Valley. The environmental factors, including agricultural management practices, that drive these differences need to be investigated.

There are other issues that also need to be addressed. Recent research has shown that soil fungi, including some species of Fusarium, are important food sources for earthworms. As Fusarium wilt is a major problem for Australian cotton growers, it is possible that a more robust soil fauna community, particularly earthworms, could reduce the incidence of Fusarium.

Better linkages between above and below ground ecological studies in Australian cotton ecosystems would tie all this together. Research elsewhere has shown that soil biota can influence the abundance and diversity of leaf feeding pests such as aphids by stimulating plant growth and improving nutrient content. Further work is needed to test for linkages between the activity of soil fauna, nutrient supply and the status of leaf pests.

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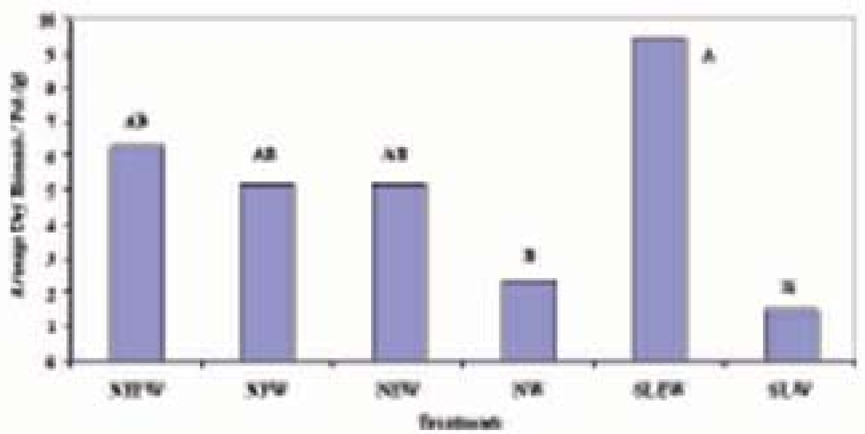
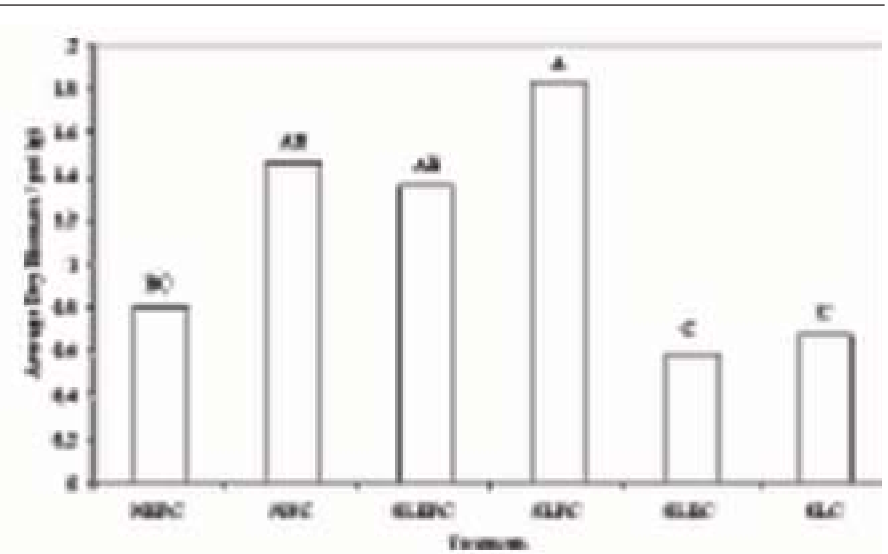
FIGURE 2: Average dry biomass of wheat plants (W) growing in sandy loam (SL) or Narrabri (N) soil, with earthworms (E) or without (no symbol) earthworms, and with (F) or without (no symbol) fertiliser



Different letters above the bars indicate significant differences between treatments

FIGURE 3: Average dry biomass for cotton plants (C) growing in sandy loam (SL) or Narrabri (N) soil, with earthworms (E) or without (no symbol) earthworms, and with (F) or without fertiliser (no symbol)



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