Natural England Commissioned Report NECR100

Managing soil biota to deliver ecosystem services

Annex E – Case study five: Dairy with some arable cropping

First published 04 October 2012

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Dairy with some arable cropping: Medium loamy soils

- Mixed methods for on-farm manure handling – reduced direct use of slurry and increased composting.
- Use of compost teas as soil treatments.
- Use of mycorrhizal fungal inoculants.

I met the group in M's kitchen; they'd gathered together mid-morning as they had done regularly since July 2007 to see, walk and discuss issues that mattered to their farming systems. Initially a handful of local farmers had got together because of their similar farming systems (dominantly organic dairy). The aim was to optimise forage yields and quality to benefit the livestock and to maximise profit. Soil was discussed at the first meeting - or at least building soil fertility for the forage and arable crops in the farming system. Members kept looking at ways to save on input cost and maintain or improve crop yield. Crowded around the table at today's gathering are more than 15 folk, attracted from a 40-mile radius.

There was a small pot of funding to support farmer discussion groups and the group decided to bring in some experts to walk and talk with them. On-farm meetings looked at crop rotations with advisors and linked in to the Think Soils training available through the Environment Agency. They dug, poked, prodded and sampled together and then discussed what they found. The group are excited about how it has benefitted them: "I have learned a lot and would recommend everyone to talk to other farmers with the same mind set; get a sense of what has worked and tweaks that have turned failure into success. Share and pool your information with others."

Garforth *et al*. (2003) found that the most prevalent source of information used by farmers to support change was other farmers, but that facilitation to provide assistance or support in using the information is also important. Facilitated farmer groups (for example, the Landcare approach in Australia; the Consultancy Officer approach in the dairy sector in New Zealand) are also a commonly reported means of sharing knowledge and promoting learning among farmers.

Management and handling of farm wastes was a key issue – several farms fell inside the boundaries of Nitrate Vulnerable Zones and so the new requirements made them think differently about things they done for years. A chance meeting between the facilitator and the main contractor for green-waste composting locally led to a series of visits to see several farms that carried out on-farm composting. As a consequence members have reduced the use of slurry on farm and increased the active composting of their farmyard manures. “We knew composting was a biological process; as we talked and discussed we realised that **the same sort of biological processes were powering our soils on farm too**”. The more members read, listened and discussed their interest in **soils as living and interactive parts of the farm system** increased. But they still find it a struggle to balance the demands on their time - “we don’t always find the time we need to compost well”.

In 2008, three members of the group took the opportunity to get some hands-on training on composting and the soil food web. They returned excited and keen to do more. “**We learned so much about the abundance the soil had to offer; we really wanted to see how we could make our soil life work with us – instead of ignoring them** as we had been doing”. We started by getting baseline measurements and carrying out “extensive soil chemistry and soil biology analysis”.

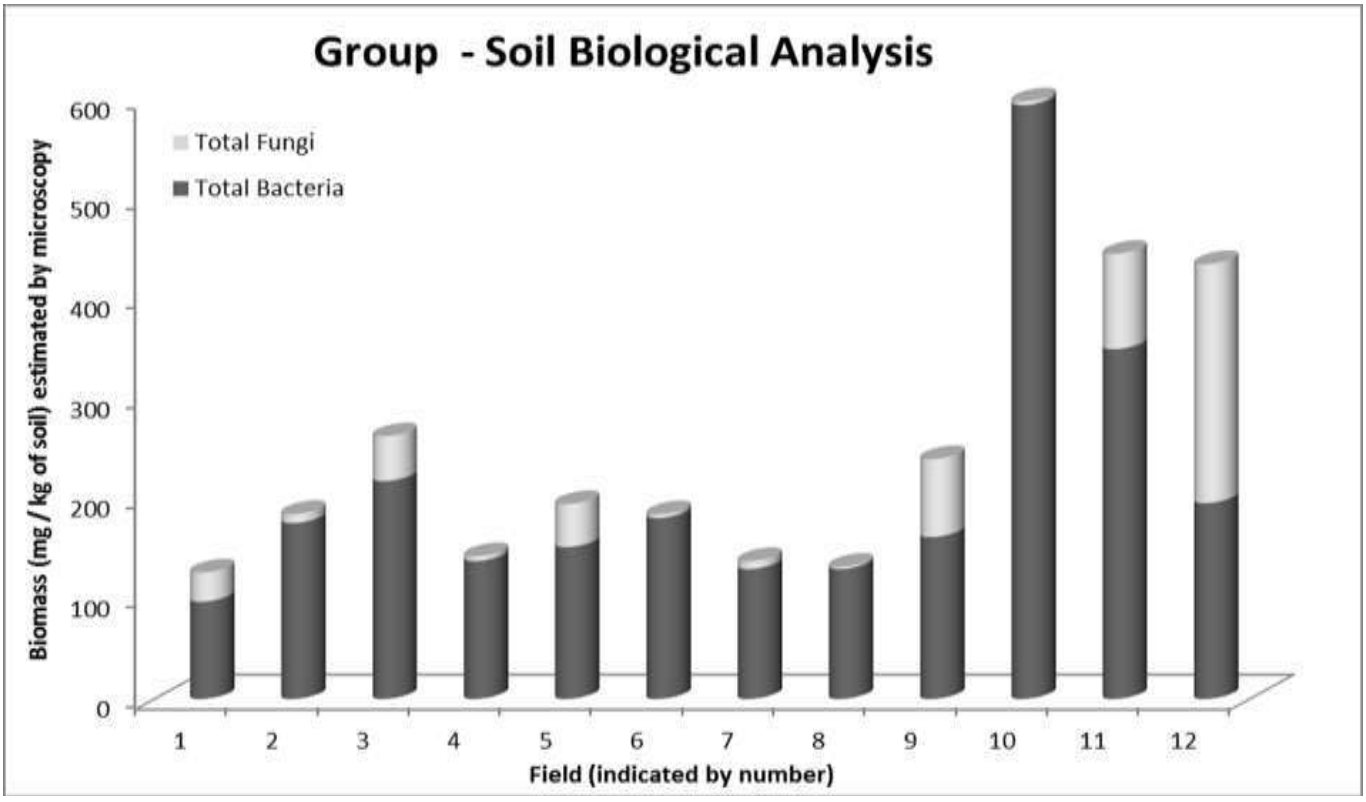
The use of organic amendments including composts and FYM seems to have no negative and often a positive effect on the biomass and effectiveness of AM fungi in forming plantfungal associations (Harrier and Watson 2003). The duration of this effect depends on the amount and quality of OM added; sustained changes are most likely where organic amendment is regular.

There is some evidence that where OM inputs are composted before addition greater increases in the biomass of the soil biota per unit C input. Short-term impact of OM additions depend on the proportion of C and other nutrients in the material that is readily available and the rates of decomposition. Variation in the decomposability of the OM inputs (often indicated by the C:N ratio), particularly the inclusion of some inputs with high lignin contents, may increase the diversity of soil biota.

A wide range of species of bacteria, fungi, protozoa, nematodes, mites, collembola, enchytraeids, earthworms, insects and other arthropods are all found in soil and spend all or part of their life cycle within it. Consequently soils contain a very high diversity of organisms; many of which remain unknown or, at least, little studied. These soil organisms not only occupy soil; they are a living part of it and as a result of their interacting activities also change it.

Commercially available analysis of soil biota is currently based on observational methods (using a microscope) but because the majority of soil species of bacteria and fungi cannot be cultured outside soil it is difficult to get a full picture of the roles these organisms play under field conditions. These data are useful in stimulating discussion and awareness of soil biota but it remains almost impossible to interpret the data robustly to guide farm management.

Detailed analysis of soil biology which was carried out late in the season (sent away for Soilfoodweb analysis) showed differences in the total populations of bacteria and fungi between farms. “The largest populations were about 5 times the smallest”. Generally there were good active populations of bacteria and fungi and some indication of bacterial dominance in the soils.



Data also showed that less than 5% of pasture roots were colonised by arbuscular mycorrhizal fungi (AMF). In discussing the results on a farm by farm basis, and "deciphering the meaning of things we'd never heard of, we became aware of the roles and potential importance of fungi especially AMF". The group tried a seed dressing with AMF in a split field and found better germination, fewer weeds and less fungal disease where AMF were applied, than where they were not. AMF seed dressing is now often used by members. "Samples sent for AMF analysis showed that over 50% of the root length was colonised".

The interest of the group in soil and especially the interactions of soil biota driving the processes continues to grow. Although they know they have learned a lot over the last 4 years, "**we know we have not even scraped the surface of the biological opportunities that soils have to offer, we feel like we still have our L plates on**". The group continues to try out practices on split fields and implement those things that make a difference to crop and pasture yields or quality. "Everyone should think about how you work your soil and about the impact of inputs on soil – we have learned that when we look after the soil biota they can help look after our farm -and our profit margin"

Very close relationships between AM fungi and plants are widespread in nature; the fungus has part of its structure within the plant root and the hyphae extend widely into the surrounding soil. These relationships are largely mutualistic so that the fungus obtains at most of its sugars from the plant, while the plant benefits from the efficient uptake of mineral nutrients (or water) by the fungal hyphae. The plant-fungus association is of further value to the plant regulating C allocation below-ground, mediating plant /plant exchanges of C and nutrients; regulating water and ion movement through plants; regulating photosynthetic rate; and giving protection from some root disease and root herbivores.

Evidence from experimental trials evaluating the use of AM fungi as a routine inoculum at a field scale has found that even where the inoculum is appropriate to the site and viable on application, it is difficult to ensure that the added microbes will persist in the soil and form effective plant associations. Little effect on plant growth has been recorded outside pot-scale trials.

Where such interventions have been adopted on-farm, they usually form part of a set of changed practices, which include a range of system-oriented changes to the management of OM inputs and tillage. Hence distinguishing the impact of inoculation may not be easy in on-farm trials.