Naturally Reducing Dependency on Synthetic Fertilisers and Other Chemicals - A Novel Approach to Soil Health Assessment

Located in Hampshire UK and set up by former F1 racing driver Jody Schekter, Laverstoke Park Farm is an organic and biodynamic operation producing an eclectic range of crops and livestock, including a herd of water buffalo. At the foundation of the farm's approach is the maintenance of a diverse and healthy soil biological population. This is because the soil is a highly complex ecosystem and the organisms living within it are critical to its quality and ultimately that of the farm's produce. Consequently, the farm has established the only licensed Soil Foodweb Laboratory in Europe. Utilising this proprietary soil health testing technique, the laboratory studies the activity of different groups of beneficial microorganisms in the soil on behalf of a variety of farms, forests and even golf courses throughout Europe.

Soil biology is often neglected, but is critical to a healthy farming environment. Soil Foodweb testing provides a way of implementing a biological approach to soil health which has helped growers to reduce their dependency on synthetic fertiliser and other chemical inputs as the soil biological activity increases. This testing technique was originally established by Dr Elaine Ingham at Oregon State University, USA, and is now commercially established and used by growers around the world. This article discusses Soil Foodweb testing in more detail and how it is now helping growers globally to maintain a healthy farming environment naturally.

Why Soil Life is Important

Micro-organisms perform a multitude of roles in the soil, including decomposing organic matter and in doing so releasing nutrients to the plant. The activity of soil micro-organisms also improves the water holding capacity and the structure of the soil. This makes the soil more porous, allowing better root penetration, which in turn means that plants have greater access to oxygen, nutrients and water. Through their role in nutrient cycling and decomposition of organic compounds, such as pesticides, micro-organisms can also affect the amounts of pollutants in the environment. Maintaining a healthy balance of beneficial micro-organisms can also actively keep out plant pathogens by either preying on them directly, or by enhancing general plant health. All of which helps to achieve a more sustainable farm.

The Soil Foodweb Test

The soil food web is a complex, interdependent, mutually beneficial group of organisms including bacteria, fungi, protozoa, nematodes, microarthropods, worms and beetles. In the process of feeding on plant materials and each other, these organisms also produce hormones that plants need, as well as consuming or breaking down pollutants in the soil. In addition, the soil food web protects plant surfaces from disease-causing organisms and other pests.

Modern agriculture's use of toxic chemicals to destroy specific pathogen and pest organisms has also destroyed these beneficial, protective organisms. After 30 to 50 years of indirect 'warfare' against the natural set of beneficial organisms in soil, disease and pests have become nearly impossible to control in some locations. Consequently, restoring the soil food web is essential to rebuilding healthy soils.

The Laverstoke Park Farm Soil Foodweb Laboratory provides a comprehensive soil test to analyse the soil biology in order to assess its health. Using a specialised microscope (the Olympus BX51, see Figure 1) the laboratory performs direct counts of the different groups of soil microbes. All Soil Foodweb labs globally have an evolving database currently consisting of several thousand results observed in soils from all over the world. By comparing a particular soil test result to soils where the required plant or related plant species are growing in native ecosystems, Laverstoke Park Farm laboratory can subsequently tailor a biological program in order to correct any microbial imbalance in the soil under analysis.

In addition to soil samples, the laboratory is also able to assess the biological health of compost, compost tea (water extract from cold brewed compost)[1] and leaf samples to ensure that any remedial work undertaken on farmland to boost microbial biomass is of value. Compost or compost tea if not correctly treated can contain minimal active microbial biomass and will therefore have no impact on soil health when applied to it.

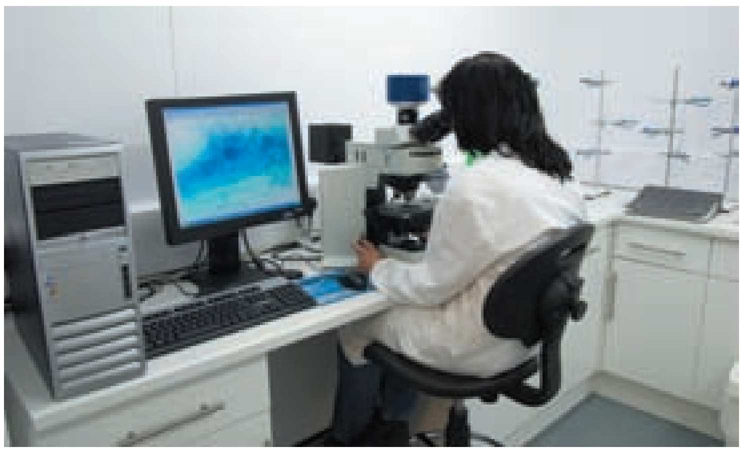

Figure 1: The Olympus BX51 microscope is used for differential interference contrast (DIC) and fluorescence microscopy at the Laverstoke Park Farm Soil Foodweb Laboratory

The Laverstoke Park microbiology laboratory assesses the following microorganism groups for the Soil Foodweb Test:

Total Bacteria and Total Fungi

The optimal bacterial and fungal biomass in the soil varies according to crop, climate and season. If it is not within the optimal range, bacteria or fungi may need to be boosted within the compost or compost tea that is applied to the soil.

Active Bacteria and Active Fungi

Only that percentage of the bacteria and fungi which are currently metabolising organic compounds are directly nourishing the plants; if this portion is too low, specific microbial foods may be required to stimulate the dormant population.

Protozoa

These single-celled micro-organisms feed primarily upon bacteria and in doing so, excrete nitrogen in plant-available form. A diverse protozoa population consisting of flagellates, amoeba and ciliates are, therefore, essential to healthy plant growth to cycle and release nutrients to the plant.

Nematodes

An exceptionally diverse group of very small worms which are ubiquitous in the environment (Figure 2). With the exception of plant parasitic nematodes, these soil dwellers predominantly help recycle nutrients by feeding on bacteria and fungi or even other nematodes. Hence, soil nematodes must be grouped depending on their feeding habits.

Figure 2: Plant parasitic nematode (200x magnification

Mycorrhizal Colonisation

Over 90% of all plants on earth form symbiotic relationships with mycorrhizal fungi (Figure 3). These fungi increase nutrient uptake (particularly Phosphorus) and protect the plant against pathogens. The Soil Foodweb Test determines the percentage of root colonisation.

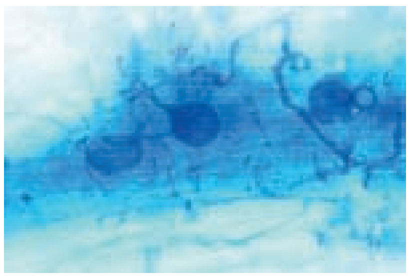

Figure 3: Symbiotic association of Mycorrhizal fungi and the plant root (200x magnification)

Leaf Organisms

This test determines the microbial colonisation on the leaf surface. This is particularly useful for comparing before and after compost tea applications. Adequate coverage of leaf surfaces by beneficial micro-organisms can help reduce pests and diseases.

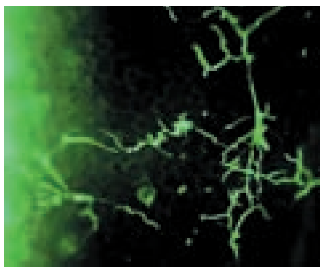

Figure 4: Example of active fungi and bacteria stained using FDA fluorescent dye, viewed under epi-fluorescence microscope (200x microscope)

In order to effectively measure and differentiate between these organisms, both differential interference contrast (DIC) and fluorescence microscopy techniques are undertaken using Olympus BX51 microscopes. DIC offers a means of swiftly assessing total bacteria and fungi within a sample, whereas fluorescence microscopy utilising FITC and FDA staining enables active bacteria and fungi to be directly counted (Figure 4).

Interpreting the Soil Foodweb test

Any field, forest, pasture or even golf course has a unique soil food web with a particular proportion of bacteria, fungi and other groups, in addition to a certain level of complexity within each group of organisms in terms of numbers of species. These differences are due to soil, vegetation and climate factors, as well as land management practices.

A Soil Foodweb test enables a snapshot assessment to be made of the complexity of the 'structure' of a particular food web with regards to its composition and relative numbers of organisms in each group. For example, the ratio of fungi to bacteria is characteristic to the type of soil ecosystem. Grasslands and agricultural soils usually have bacterial-dominated foodwebs. Highly productive agricultural soils tend to have ratios of fungal to bacterial biomass of around 1:1 or less. However, forests tend to have fungal-dominated food webs where the ratio of fungal to bacterial biomass may be 5:1 to 10:1 in a deciduous forest; and 100:1 to 1000:1 in a coniferous forest.[2]

Having established the particular foodweb structure via the test, by then consulting the globally derived Soil Foodweb database, the laboratory can ascertain what remedial actions are required to optimise the structure for a particular location and crop type. Depending on the required land use, there are various 'natural' actions that can be undertaken to enhance the structure and complexity of a particular soil foodweb. These include altering land management practices, such as crop rotation and reduction in tillage, and application of composts.

For example, a field with a 4-year crop rotation, when compared to one with a 2-year rotation, may have a greater variety of food sources (ie roots and surface residue), and therefore is more likely to have a greater variety of bacteria, fungi and other organisms. Furthermore, in reduced tillage agricultural systems, the ratio of fungi to bacteria increases over time, and earthworms and arthropods become more plentiful.

Compost and compost teas of varying microbial compositions can be applied depending on the required soil foodweb structure and land use. The composition of the compost or compost tea, and hence the soil that it is applied to, can be altered simply by adding an inoculum of the preferred food of the microorganism that needs to be boosted. For example, bacterial foods are green, high in easy-to-use sugar and nitrogen (eg grass clippings and cover crops, such as legumes and molasses), whereas, fungal foods are brown plant materials high in cellulose, lignin and tannin (eg woody fibrous materials, such as straw and sawdust). By following a step-wise approach to repairing and developing a specific soil foodweb with the correct balance and biomass of beneficial microorganisms which ultimately enables the presence of earthworms and/or microarthropods, then plant health can be assured.[3]

Conclusion

Utilising the Soil Foodweb test to assess soil health and subsequent natural remediation activities (eg altering land management practices and application of compost and compost teas), is helping agronomists to reduce their dependency on synthetic fertilisers and other chemical inputs such as insecticides, many of which are now subject to stringent EU regulations. In the long term, this is not only financially beneficial, but also extremely advantageous to the environment and general population as a whole.

References:

[1] What is compost tea? Available: www.laverstokepark.co.uk/compost-tea-explained [March 2010]

[2] Elaine R. Ingham. Soil Biology Primer [online]. Available: http://soils.usda.gov/sqi/concepts/soil_biology/biology.html [March 2010].

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