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Yara Analytical Services
Technical Bulletin

Encouraging soil biology

Factors that effect soil biology

Soil pH

The ideal soil pH for nutrient availability and fertiliser efficiency (pH 6.5 to 7.5) is also ideal for soil biology. An excessively low or high soil pH can kill off many of the most beneficial organisms, or reduce their activity, or cause them to go into hibernation in the case of encysting organisms.

Soil Organic Matter (SOM)

Usually 1-5% of SOM consists of soil organisms, the rest being high carbon molecules such as humic acids. SOM is both the habitat and the food source of soil biology, simple compounds are decomposed quickly, mainly by bacteria, and more complex compounds are broken down over a longer period mainly by fungi. Nutrients like nitrogen are recycled by the predation of these two groups by protozoa and some nematodes. For example, the C:N ratio in bacteria is approx. 3:1 but in protozoa it is approx. 10:1. As protozoa prey on bacteria, the excess N is released in a plant available form. SOM builds soil structure, which aids the growth of soil biology and provides a stable environment to prevent losses due to water erosion.

Compaction

Compaction causes a low oxygen environment within the soil. This changes the conditions, chemistry and ability of the soil to support life in the form of microbes and plants. Most of the beneficial microbes in the soil are aerobic and need oxygen to stay alive. Anaerobic organisms produce different by-products that are not as useful to the plant, and breakdown of lignin (woody material) can only be performed by a select few organisms which are all aerobic. Therefore, plant residues will only decompose and return nutrients to the soil if soil conditions are good. Nitrification and denitrification balances also change under anaerobic conditions reducing fertiliser efficiency.

Waterlogging

Waterlogging can have much the same effect as compaction; it results in a low oxygen level in the soil. Excess water also effectively puts a barrier between the soil and the air so, as oxygen isn't very soluble, it diffuses through the water at a much reduced rate. In addition, the balance of soil microbes changes when submerged; fungi are destroyed resulting in the soil becoming more bacterially dominated and slowing or stopping the release of high nutrient containing complex carbon compounds.

Digestate Application

Recently trials performed on the use of Anaerobic Digestate (AD) as an amendment to benefit soil biology have produced mixed results. AD has high levels of plant available Nitrogen, and can increase the SOM and bulk density of soil. However, because of the way it is produced, it will contain by-products of anaerobic organisms (see compaction) which can be toxic to the aerobic organisms which provide benefits to plants. In short, AD is a nutrient addition, bypassing the soil biology and giving a short term hit of plant available nutrients, but not necessarily benefiting soil biology on the longer term.

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Cultivation Techniques

There is a lot of research into the effects of cultivation on soil biology, most of it agreeing that minimum or no tillage systems produce net higher levels of beneficial soil microbial populations. These benefits will be due in part to the fact that cultivation often destroys fungal hyphae networks which process nutrients, decompose sessile materials and interact with plants. However, there is also an argument for cultivation in that it allows oxygen into the soil, which is beneficial for promoting aerobic biology, and that breaking up some of the networks frees up nutrients from the dead organisms to promote nutrient cycling.

There are models (Huston's equilibrium model for example) to try to predict the effects of cultivation on soil biology. Generally, disturbance in soil with high SOM is good because it prevents the domination of quickly growing organisms over the slower growing organisms. With low SOM, low disturbance is best, as there is not enough resource present to allow the quickly growing organisms to dominate, and disturbance will kill organisms both quick and slow growing, whilst producing an environment favouring mineralisation – sending the organisms (who rely on access to organic molecules) into hibernation.

Fungicides

Broad spectrum fungicides will act against beneficial fungi as well as fungal pathogens, reducing the soil's capacity to decompose complex material and transform inaccessible nutrients into useful compounds. Application strategy should therefore be considered when trying to protect the soil biology e.g. apply only when necessary and ensure, where possible, that foliar applications are not allowed to contaminate the soil.
Since fungi are slower growing, any detrimental effects are proportionally more severe than those on bacteria. As with all crop protection products, intelligent application and use only where necessary is the best course of action, as opposed to general prophylactic applications.

Pesticides

Similarly to fungicides, there will likely be collateral damage to the soil biology (especially soil arthropods) and, once again, a good management approach should be adopted.

Biocontrol and Inocculants

These represent a more integrated solution to eliminating pathogens, and will in most cases claim to avoid much of the collateral damage caused by chemical biocides. Since many biocontrol species are endemic to soil anyway, they should not have too much of a negative knock on effect on the soil biology. However, there is always a shift in competitive balance when biocontrols are added, as many are selected for their vigour and quick growth (e.g. Trichoderma and Gliocladium), as competition is one of the key biocontrol mechanisms.
In addition, they usually need to be applied at high rates. This means that the beneficial microbiology present in the soil can get pushed out in favour of some of these biocontrol organisms, reducing the level of nutrient cycling and benefit to the plant. One of the benefits of a healthy soil biology is that the natural competition means that pathogens are already at a disadvantage, and so there is an argument that biocontrols are not necessarily needed as a healthy soil biology is all that is needed to provide control.

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