The effects of herbicides on soil life

Part 2: Beneficial fungi and bacteria

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Weeds are a persistent threat to crop productivity worldwide. In an effort to optimise yield by controlling these unwanted plants, modern agriculture has become heavily dependent on the use of herbicides. Non-target organisms are unfortunately equally exposed to these chemicals which have the potential to, unintentionally, also harm them.

According to international literature, this may lead to a reduction in biodiversity and the provision of ecosystem services that support food security and on-farm profitability. Glyphosate is the world's most commonly used herbicide and has been extensively studied for its effect on soil microbial communities than any other herbicide.

In this second part of our series we will focus on some of the international findings surrounding the effects of glyphosate and other herbicides observed on the beneficial fungal and bacterial communities. Due to the sheer magnitude of research findings available, we will only highlight some of the findings published internationally and the various views surrounding this topic.

Why are fungi and bacteria important?

The simple answer to this question would be that fungi and bacteria are the decomposers in the biological world. They digest the decaying leaves and rotting bodies of plants and animals, and in so doing return their elements to the soil. Without them, the earth would basically be littered with dead organic material, and all life would cease to exist as plants will not have the required nutrients to grow, which have a knock-on effect on every living thing.

However, fungi and bacteria degrade plant residues differently and have different roles in the recycling of nutrients, which is partly due to the different habitats they prefer within the soil and the different types of organic matter they consume. Bacteria within the rhizosphere (the region of soil in the vicinity of plant roots) are involved in biogeochemical processes within the soil such as carbon, nitrogen, and phosphorus cycling.

Fungi and bacteria differ in their responses to changes in agricultural management practices with fungi usually being more sensitive to these changes. The fungal-to-bacterial ratio is therefore a good indicator of environmental changes in the soil. Based on the function of fungi and bacteria in soil, a reduction of their numbers may affect soil respiratory activity, soil enzymes and microbial diversity, as well as rates of carbon and nitrogen turnover.

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Herbicides and its effect on fungi and bacteria in general

As already indicated in Part 1 of our series (*SA Graan/Grain* September-issue), there is an overwhelming number of contradictory findings concerning the impact of herbicides on fungi and bacteria. The effects of paraquat and glyfosinate on soil bacteria and fungi are either positive or negative effects [1-4], or no significant effect at all[5].

A similar trend is observed with international research findings pertaining to glyphosate, with some studies reporting a negative effect on fungal growth[6] and reduced colonisation by beneficial bacteria[7], or negligible or minor effects on microbial community structure when glyphosate was applied at recommended field-rate (stated as 50 mg/kg)[8-12].

Other studies state that despite an initial negative effect directly after application, the rhizobacterial community managed to recover by the time the plants reached their final growth stage[13].

Researchers speculate that the reason for inconsistencies in findings can be anything from microbes reacting differently to different chemicals[11], to differences in soil characteristics[14] or to different formulations being used[15], to name but a few. Some studies, however, refute certain aspects of such speculations. A research study, published during 2012[13] concluded that although the composition of the bacterial communities differed between the soil types included in their study, the effects of the herbicides tested remained very similar with regards to the same bacterial groups.

Comparative studies have, however, indicated that not all herbicides are equally damaging. An acetochlor and terbuthylazine product evaluated, demonstrated to be in general much more aggressive than the glyphosate-based product tested in various studies[13,16].

What about herbicides and biocontrol agents?

Several Pseudomonas species have been employed as effective biocontrol agents due to their production of a range of antibiotic compounds, iron-scavenging molecules and plant growth promo-