New knowledge, new language

David Way

Although we live in the 21st century, the common language of gardeners today is still strongly Victorian, in both vocabulary and expression.

Advances in plant science in the last few decades have brought dramatic discoveries, and an ever-increasing number of words, and concepts, are forming part of a scientific language some of us find hard to understand. The challenges I have encountered after moving in 2012 from an old established garden to a new blank space accompanying a newly built house set me on a steep learning curve, focusing in particular on the rhizosphere and what goes on there.

Well, even if you had never read the word **rhizosphere** before, it appears pretty self-explanatory at first glance: the upper soil layer occupied by plant roots. But that is a totally inadequate definition, hiding the fact that it is also occupied by a dense and diverse range of living organisms other than plant roots. It is a hidden world of great complexity. Many of its inhabitants, such as many fungi and bacteria, never appear above soil level, and are invisible to the naked eye even if the soil is turned over with a fork.

Soil science is revealing more and more about the rhizosphere: not just what organisms live there, but how they **interact** one with another. How one organism can influence, for better or worse, another organism. How one organism can become totally dependent on another for survival. Of course where scientific discovery leads, commercial exploitation often follows: a topical example is the commercial production of mychorrhizal fungi.

There are two broad groupings of mychorrhizal fungi. Ectomychorrhizal species, referred to as **ECMFs**, form a sheath around plant roots for the purpose of exchanging water and nutrients. They associate with trees and may form fruiting bodies above or near ground level. One well known example is the truffle. The other group is Arbuscular Mycorrhizal Fungi, referred to as **AMFs**, which penetrate the cortical root cells of their plant hosts. This group form symbiotic relationships with most plants, with two notable exceptions – members of *Brassicaceae* and *Ericaceae*. They do not form visible fruiting bodies.

For commercial reasons, the approach of firms selling mycorrhizal products has been to aim wide, with formulations normally contain between 5 and 18 different AMFs. This seems a blunderbuss approach: pull the trigger and you are bound to hit something, even if it is not what you were aiming at. Some products also contain other beneficial fungi and bacteria, to broaden the product's scope and potential use. The product range is often expanded to include several formulations aimed at different situations or circumstances, all of which can make the choice of the right product confusing. The best advice is to improve your knowledge of the subject and investigate the ingredients in each product. In theory, a product with a large number of different AMF species is unlikely to be needed, because in general AMFs are not host-specific, forming symbiotic links with a range of plant species, sometimes simultaneously. The important thing to remember is that when AMFs are introduced to soil, the AMF content of a product (spores and mycelial fragments) require direct contact with roots to trigger germination and development.

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A product combining eighteen mycorrhizal fungi (nine AMFs with nine ECMFs), plus eight species of PGPR bacteria with several species of the beneficial fungus *Trochoderma* and trace elements. Quite a blunderbuss.

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A product combining charcoal with an undeclared number of mycorrhizal fungi and other beneficial soil microbes plus trace elements. Such products are described as Enriched *Biochar*.

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A product containing five species of plant-growth-promoting rhizobacteria.

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A product containing five separate mycorrhizal fungi only. In this case three are arbuscular species and two are ectomychorrhizal species.

This is the basis of the recommendation to put the product in the planting hole before lowering the root ball into it.

Are there alternatives to commercial AMF products? Yes, according to Professor Davey Jones of Bangor University, as he demonstrated last year on BBC Gardener's World. Although most plants form symbiotic associations with AMFs, he suggests some may be more adept than others. Because up to 95% of the roots of *Plantago lanceolatea*, a common weed of uncultivated areas, form symbiotic connections with AMFs, he suggests sowing seed of this plant in pots of soil already containing natural AMFs and later, when the plants are well grown, breaking up the root balls to use as an additive to commercial potting compost. Clearly his message is that plants eventually need to live in the real world, not an artificially sterile one.

Measuring the benefits of AMF use has been difficult in the past but, now that microbes are increasingly used in horticulture, convincing evidence of benefit is more readily available. A notable example can be found in

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Pure charcoal. A grade composed of small lumps and powder such as this can be referred to as *Biochar*. Its structure is highly microporous and provides an attractive environment for many microbes in the rhizosphere.

commercial strawberry culture. To meet the demand for strawberries all year round, the bulk of the crop now comes from strawberries grown in plastic tunnels; this means that irrigation is essential, causing a huge and unsustainable demand for mains water. Now millions of young potted strawberry plants, already inoculated with AMFs, are sold to fruit growers, which reduces the consumption of water by up to 60%.

Water transfer is just one of the benefits of these symbioses; nutrient transfer and disease control can be others. Another example comes from the sports-turf industry: grasses are highly mycorrhiza-dependent, which has led to the widespread use of seed coated with AMFs to speed up establishment, suppress damping-off, and maintain sports turf in top condition more cheaply.

More scientific study has been devoted to mychorrhizal fungi than other soil microbes, so until now they have received much more publicity than other inhabitants of the rhizosphere. This is changing as scientific work continues.

We are constantly being informed, largely through medical science, not just of the vast number of bacteria in the dirt below our finger nails, but of their diversity and ubiquity. It can be no surprise to find that this includes the rhizosphere. Scientific study is revealing remarkable facts about a group known as Plant Growth Promoting Rhizobacteria, commonly referred to as **PGPRs**. Professor Duncan Cameron of Sheffield University, a leading expert in this field, is making amazing discoveries about the role of these bacteria in association with AMFs. His studies lead to the realisation that plants have immune systems. Two such systems are recognised: Systemic Acquired Resistance **(SAR)** and Induced Systemic Resistance **(ISR)**. Already commerce has grasped the opportunity these discoveries provide. Two global companies already have products on sale. Bayer produce their own patented form of the bacterium *Bacillus subtilis* under the trade name Serenade, and sell it for the control of a range of fungal diseases. Monsanto market, though not yet in Europe, their own patented form of *Streptomyces lydicus* under the trade name Actinovate for the control of several root rots and to control lawn diseases. This appears to be a great leap forward in finding eco-friendly approaches to pest- and disease-control. It is based on a physiological property of plants many of us never knew existed, that plants too have immune systems, and that these can be stimulated, quite quickly, by other living organisms.

Alongside the living organisms discussed above, perhaps mention should be made of an inert material, charcoal. It is certainly topical in this context because claims are being made for its benefits when integrated with many rhizosphere microbes. Apparently charcoal has the valuable physical structure of providing vast numbers of microscopic pores which many microbes use for temporary shelter. As a result, a fine grade of charcoal called Biochar is traded for use on and in soil. When it is compounded with AMRs and PGPRs the term Enriched Biochar has come into use to distinguish it from plain Biochar. At least one Enriched Biochar product is marketed for domestic and commercial use, but a less sophisticated homemade mixture is worth trying.

The intelligent use of soil microbes is expanding through amenity, sports and commercial horticulture, altering attitudes and cultural practices. Although we are often regarded as very conservative, gardeners must not be left behind. This overview may help gardeners be aware of the potential for changed practices behind our fences and hedges, and to understand the new language of our basic asset, the soil we stand on.

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