Ground rules

Understanding soil fertility

By LYN ABBOTT

Soil fertility reflects the physical, biological and chemical state of soil and the interplay between them.

For soils managed under certified organic practices, this interplay depends greatly on biological processes that enable nutrients to be released from poorly soluble minerals and from organic matter at a time suitable for use by plants.

It is well-known that both soil animals and micro-organisms of various kinds contribute to these processes. But the balance between them, such as processes that lead to release of nutrients and soil binding properties resulting from activities of these soil animals and micro-organisms, is less than well-understood.

In some cases, these processes are linked (such as when micro-organisms degrade organic matter and release nutrients into soil and simultaneously produce glue-like substances which contribute to aggregating soil particles together, either strongly or weakly).

In other cases, the biological processes in soil are carried out independently of one another. For example, invasion of roots by nitrogen-fixing bacteria is a process independent of multiplication of protozoans in response to bacterial growth on surfaces of organic matter.

As a result of some processes being linked while others are not, it follows that processes can be affected quite differently by soil management practices. All management practices change soil conditions to some extent and this affects the growth of micro-organisms – but it might affect organisms in different ways.

Thus, the soil biological processes they are involved in are also affected to different extents. By understanding the way soil organisms are affected by changes in their environment, it is possible to predict which types of soil management will influence soil biological fertility in a favourable manner.

This information can be used to maximise nutrient supply to plants and ensure nutrients are used efficiently and not lost from the root environment. ■

Professor Lyn Abbott is Head, School of Earth and Geographical Sciences, in the Faculty of Natural and Agricultural Sciences at the University of Western Australia.

Organics courses at UWA

Professor Lyn Abbott teaches at undergraduate and postgraduate classes at the University of Western Australia that investigate organic agriculture, horticulture and viticulture.

The aim is to enable students to explore issues related to organic farming and to evaluate and conduct scientific experiments and economic evaluations concerning organic production systems.

While it is not intended to teach the practice of organic farming, the scientific and economic analysis of the practices used makes it possible to explore issues related to organic farming in different landscapes, soils and climates.

The environmental impacts of organic farming can also be evaluated. Less emphasis is placed on comparing organic and conventional farming systems than on evaluating organic practices in their own right.

A new postgraduate degree program covers soil management and this may have emphasis on organic agriculture, horticulture or viticulture (see website for further details: <www.segs.uwa.edu.au>. This program includes a graduate certificate, graduate diploma and Masters by coursework and research. ■

LEFT: Postgraduate students from four Australian universities in Denmark being introduced to organic farming practised under very different conditions to those of Australia

This healthy soil has been exposed to organic practices for several years.

Replacing nutrients safely

In a review in the book *Organic Agriculture: a Global Perspective*, edited by A Taji and P Kristiensen (to be published by CSIRO Publishing later this year), Jennifer Davis and Lyn Abbott consider the long-term prospects of maintaining soil fertility under organic farming systems.

Clearly, nutrients are lost from organic farming systems when produce is sent to market. Thus, inputs are necessary to replace these nutrients, especially in many Australian soils that are relatively old and highly weathered, compared with other parts of the world (such as in areas of western Europe and North America).

The challenge is to replace nutrients in a manner that does not minimise the activities of beneficial biological processes. It is ironic that adding nutrients can decrease some components of biological activity in soil, so it is necessary to select the right amount and kind of nutrients that stimulate rather than inhibit microbial activity.

In Australia there is relatively little scientific investigation of the way nutrient inputs registered for organic farming affect soil biological processes.

Although it is common knowledge that organic farming practices provide a beneficial environment for soil microbial processes, this has not been well-researched in Australian soils.

Indeed, evaluating the biological state of soils is not easy because there are so many processes that could be measured and the levels of activity and abundance of organisms involved can change quite suddenly (say, after rain).

Thus, the time of sampling soil to measure activities and abundance of organisms needs to be considered carefully. ■

10 KEY PRINCIPLES

Professor Abbott has summarised 10 key principles of soil biological fertility (see the soilhealth.com website) and noted the corresponding soil management practice associated with each:

1 Soil organisms are most abundant in the surface layers of soil, therefore soil erosion should be controlled to minimise loss of soil organisms.

2 Soil organic matter is necessary for nutrient cycling and soil aggregation, therefore plant organic matter should be retained to maximise nutrient cycling and soil aggregation processes.

3 Maximum soil biological diversity depends on diversity of organic matter and habitats, therefore some disturbance of soil is necessary to maximise soil biological diversity.

4 Nitrogen-fixing bacteria form specific associations with legumes under specific conditions, therefore nitrogen-fixing bacteria should be selected that match the host, soil characteristics (such as pH) and environmental conditions.

5 Nitrogen is released during organic matter breakdown, either into soil or into the soil micobial biomass, therefore inputs of nitrogen fertliser should be calculated to complement nitrogen cycling from organic matter.

6 Arbuscular mycorrhizal fungi can increase phosphate uptake into plants in P-deficient soils, therefore inputs of phosphorus fertiliser should be calculated to complement and enhance the activities of arbuscular mycorrhizal fungi.

7 Soil amendments can alter the physical and chemical environment of soil organisms, therefore any substance added to soil should be assessed in terms of its effects on soil biological processes and soil biological diversity.

8 Some crop rotations and tillage practices decrease the suitability of soil for plant pathogens, therefore crop rotations and tillage practices should be selected to avoid development of soil conditions that enhance growth and survival of plant pathogens.

9 Production systems based on soil biological fertility can be profitable, therefore the capacity of a management practice to produce a commercial product should be considered in parallel with its capacity to maintain and/or increase soil biological fertility.

10 Soil biological processes develop slowly, and the time required will differ for different soils, environments and land management practices, therefore sufficient time should be allowed for establishing or restoring a level of soil biological fertility appropriate for particular soils and land management. ■