

## Soil bacteria

Bacteria are some of the smallest and most abundant microbes in the soil. In a single gram of soil, there can be billions of bacteria. There are an estimated 60,000 different bacteria species, most which have yet to be even named, and each has its own particular roles and capabilities. Most live in the top 10cm of soil where organic matter is present.

### Characteristics of bacteria

Some bacteria species are very fragile and can be killed by slight changes in the soil environment. Other species are extremely tough, able to withstand severe heat, cold or drying. Some can lie dormant for decades waiting for favourable conditions. Others can extract nitrogen directly from the air or break down some toxic substances.

Populations of microbes can boom or bust in the space of a few days in response to changes in soil moisture, soil temperature or carbon substrate. To gain advantage in this process, many microbes release antibiotic substances to suppress particular competitors. In this way some species can suppress other disease-causing microorganisms.

### Types of bacteria

#### Decomposers

Bacteria play an important role in decomposition of organic materials, especially in the early stages of decomposition when moisture levels are high. In the later stages of decomposition, fungi tend to dominate. *Bacillus subtilis* and *Pseudomonas fluorescens* are examples of decomposer bacteria. Additions of these bacteria have not been proved to accelerate formation of compost or humus in soil.

#### Nitrogen fixers

*Rhizobium* bacteria can be inoculated onto legume seeds to fix nitrogen in the soil. These nitrogen-fixing bacteria live in special root nodules on legumes such as clover, beans, medic, wattles etc. They extract nitrogen gas from the air and convert it into forms that plants can use. This form of nitrogen fixation can add the equivalent of more than 100kg of nitrogen per hectare per year.

*Azotobacter*, *Azospirillum*, *Agrobacterium*, *Gluconobacter*, *Flavobacterium* and *Herbaspirillum*

are all examples of free-living, nitrogen-fixing bacteria, often associated with non-legumes. To date, inoculating the soil with these organisms has not proved an effective means of increasing nitrogen fixation for non-legume crops.

#### Disease suppressors

*Bacillus megaterium* is an example of a bacterium that has been used on some crops to suppress the disease-causing fungus *Rhizoctonia solani*.

*Pseudomonas fluorescens* may also be useful against this disease. *Bacillus subtilis* has been used to suppress seedling blight of sunflowers, caused by *Alternaria helianthi*.

A number of bacteria have been commercialised worldwide for disease suppression. However, suppression is often specific to particular diseases of particular crops and may only be effective in certain circumstances.

#### Aerobes and anaerobes

Aerobic bacteria are those that need oxygen, so where soil is well drained aerobes tend to dominate. Anaerobes are bacteria that do not need oxygen and may find it toxic. This group includes very ancient types of bacteria that live inside soil aggregates. Anaerobic bacteria favour wet, poorly drained soils and can produce toxic compounds that can limit root growth and predispose plants to root diseases.

#### Actinobacteria

These soil bacteria help to slowly break down humates and humic acids in soils. Actinobacteria prefer non-acidic soils with pH higher than 5.

#### Sulfur oxidisers

Many soil minerals contain sulfides but this form of sulfur is largely unavailable to plants. *Thiobacillus* bacteria can convert sulfides into sulfates, a form of sulfur which plants can use.

### Management of bacteria

Though largely unaffected by cultivation, bacteria populations are depressed by dry conditions, acidity, salinity, soil compaction and lack of organic matter. Except in the case of certain seed inoculations, it is very difficult to build desirable populations of bacteria just by adding them to the soil. If



populations of soil bacteria are low, it is probably because conditions are unfavourable, so any new additions are likely to suffer the same fate.

A more effective approach to bacteria management is:

- address soil health problems such as acidity and compaction
- ensure that there is a good ground cover of grass or mulch
- build organic matter through practices such as green manure crops, mulching, strategic grazing and minimum tillage.

Each of these measures has multiple benefits and will also support healthy populations of soil bacteria.

Poor drainage encourages undesirable anaerobic bacteria. Reducing compaction and building soil organic matter will improve water infiltration without compromising moisture storage and will discourage anaerobic bacteria.

## Key points

- Populations of soil bacteria change rapidly depending on moisture, time of year, type of crop, mulching, etc.
- Healthy populations of soil bacteria are encouraged by ground cover and organic matter.

## More information

*Soil biology basics* is an information series describing basic concepts in soil biology. For more detailed information we recommend the Australian book *Soil biological fertility: A key to sustainable land use in agriculture* (2003), edited by Lyn Abbott & Daniel Murphy.

NSWDPI has online soil biology information at <http://www.agric.nsw.gov.au/reader/soil-biology>.

The University of WA has online soil biology information at <http://ice.agric.uwa.edu.au/soils/soilhealth>.

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**Department of Primary Industries**

The information contained in this publication is based on knowledge and understanding at the time of writing (2005). However, because of advances in knowledge, users are reminded of the need to ensure that information on which they rely is up to date, and to check the currency of the information with the appropriate officer of NSW Department of Primary Industries or the user's independent adviser.